

Spotlight on Careers in Digital Health and Care

Addressing future workforce development needs in Digital Health and Care

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Table of Contents

Table of Contents	2
Foreword.....	4
Executive summary.....	5
Summary of recommendations	6
1 About this report	6
1.1 Introduction and background	8
1.2 Occupational categories	9
1.3 Research methodology and analysis	10
2 The expansion of the Digital Health and Care sector.....	12
3 “21st Century Skills Plus”	16
3.1 Skills categories on the Heat Map	19
3.2 Occupational categories on the Heat Map.....	20
3.2.1 Translational categories.....	23
3.2.2 Core skills	25
3.2.3 Skills showing the division between technical and domain specialist jobs	26
3.2.4 Specialist skills.....	28
4 The six occupational categories.....	30
4.1 Software developers / engineers	30
4.1.1 Description.....	30
4.1.2 Findings: Software Developers	31
4.1.3 How skills are learned	32
4.2 Product Owners	33
4.2.1 Description.....	33
4.2.2 Findings: Product Owners	34
4.2.3 How skills are learned	35
4.3 Implementation Facilitators.....	36
4.3.1 Description.....	36
4.3.2 Findings: Implementation Facilitator	37
4.3.3 How skills are learned	37
4.4 Knowledge Engineers	38
4.4.1 Description.....	38
4.4.2 Findings: Knowledge Engineers	40
4.4.3 How skills are learned	40
4.5 Health Data Analysts	42
4.5.1 Description.....	42
4.5.2 Findings: Health Data Analysts	43
4.5.3 How skills are learned	44
4.6 Cyber Security Specialists	45
4.6.1 Description.....	45

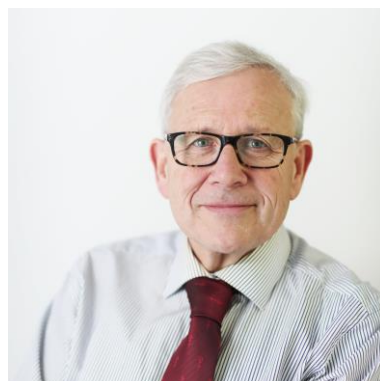
4.6.2	Findings: Cyber Security Specialists	47
4.6.3	How skills are learned	48
4.7	Three proposed roles for cyber security in the health and care context.....	49
4.7.1	“Cyber Security Consultant”	49
4.7.2	“Cyber Security Administrator”	50
4.7.3	“Cyber Security Architect”	51
5	<i>Addressing future workforce development issues in the Digital Health and Care.....</i>	52
5.1	Raising awareness of career opportunities in Digital Health and Care	52
5.2	Recognising and defining the translational jobs category.....	53
5.3	Taking advantage of the shared skills basis across categories	53
5.4	Making the sector more attractive	54
5.5	Signposting graduates into careers in digital health and care.....	55
5.6	Creating early career pathways for highly specialised jobs.....	56
5.7	More opportunities for upskilling/reskilling to enhance careers	57
5.8	Renewing Health Data Analyst education.....	57
6	<i>Recommendations</i>	58
7	<i>References.....</i>	59
Appendixes.....		63
Appendix 1a:	Interview schedule.....	63
Appendix 1b:	Project Information Sheet and Consent Form	65
Appendix 2a:	Career maps – Software Developers	70
Appendix 2b:	Career maps – Health Data Analysts	72
Appendix 2c:	Career maps – Product Owners	74
Appendix 2d:	Career maps – Knowledge Engineers	77
Appendix 2e:	Career maps – Cybersecurity Specialists	79
Appendix 2f:	Career maps – Implementation Facilitators	81
Appendix 3:	Skills and Capabilities Framework - Discussion.....	83
Appendix 4:	Updated Digital Health and Care Market Analysis.....	90
Appendix 5a:	Full Skills and Capabilities Table for Software Developers	93
Appendix 5b:	Full Skills and Capabilities Table for Product Owners	95
Appendix 5c:	Full Skills and Capabilities Table for Implementation Facilitators.....	97
Appendix 5d:	Full Skills and Capabilities Table for Knowledge Engineers	100
Appendix 5e:	Full Skills and Capabilities Table for Health Data Analysts	103
Appendix 5f:	Full Skills and Capabilities Table for Cyber Security Consultant	105
Appendix 5g:	Full Skills and Capabilities Table for Cyber Security Administrator.....	107
Appendix 5h:	Full Skills and Capabilities Table for Cyber Security Architect	109
Appendix 6:	Heat Map	111

Foreword

The world of work is ever-changing. The challenge for today is to ensure that educational institutions prepare the workforce of tomorrow by giving them the knowledge, skills and expertise that allows them to actively contribute in the workplace. This is true across all aspects of society. However, the issue is magnified when you look at one of the new economic growth areas, digital health and care.

Many of the jobs mentioned in this report did not exist 10 to 15 years ago or if they did, they were on the margins rather than at the heart of a business. This is rapidly changing.

This report sets out several recommendations that could help Scotland be better prepared to address these challenges. It recognises that while specialisation is important, there are also many more generic skills - soft skills – that people need to acquire in order to become well-rounded, agile contributors to the workforce. Success for Scotland in the future is not going to be determined by the technology solutions that we produce or adopt, but by our people being equipped to play an active part in developing, shaping and delivering digitally enhanced services and solutions that are both wanted and needed.

A handwritten signature in black ink, appearing to read 'G Crooks'.

Professor George Crooks OBE MBChB FRCP FRCGP

Chief Executive Officer at the Digital Health & Care Institute

Executive summary

The 4th Industrial Revolution - digitisation and automation of services, the arrival of cloud-computing, Artificial Intelligence (AI), Internet of Things (IoT), Big Data, machine learning, and more - is transforming the world of work in almost every area. The Health and Care sector is no exception: the workforce is required to be more agile and flexible to keep up with the accelerating pace of technological advancement. This pace is further amplified by the increasing ageing population and their growing health and care needs. One of the fastest growing economic sectors globally is Digital Health and Care, specifically the digitisation of health and care services. A recognised factor restricting the growth of Digital Health and Care in Scotland is the lack of a suitably skilled workforce. This is not restricted to the Health and Care sector: across the UK economy, the annual expense of skills shortages is an additional £2bn in higher salaries, recruitment costs and temporary staffing bills.

Based on earlier research carried out by the DHI, the occupational categories in most urgent need of staff in Scotland's Digital Health and Care sector are:

1. Software Developers
2. Product Owners
3. Implementation Facilitators
4. Knowledge Engineers
5. Health Data Analysts, and
6. Cyber Security Specialists.

This report, produced in partnership with Skills Development Scotland, probes into the nature of these roles and the skills and capabilities required of people employed in them; the education and career pathways taken by professionals currently engaged in these roles, and the currently available educational pathways into them. The main purpose of this study is to highlight the issues underlying the lack of clear career pathways and offer advice for organisations involved in planning the education and training provision for the (Digital) Health and Care sector in Scotland.

Based on desk research and qualitative in-depth interviews, the study outlines the following key findings:

1. *General lack of awareness of the existing career opportunities and emerging job roles in the Digital Health and Care sector.*

While some occupational categories in the study are well-established and have recognised educational pathways (such as Software Developers), people in these areas are not aware of career opportunities in Digital Health and Care. In the case of the emerging occupational categories (such as Knowledge Engineers), there is a general lack of awareness that these job roles even exist. Fundamentally, the lack of awareness translates into a lack of well-defined education and career pathways.

2. *The emergence of a new type of occupational category: job roles at the interface of humans and technology translating data, knowledge and information between them.* These new types of translational roles are crucial in the development and implementation of digital solutions as part of the digital transformation of the Health and Care sector.

3. *The increasing importance of distinctly human soft skills across the six occupational categories.* These are skills and capabilities not replicable by technology. Current education and training system do not take these sufficiently enough into account in preparing graduates for future working life.
4. *The study shows valuable opportunities for considering common approaches to education, skills development and career planning across the six categories due to a vast, shared skills and capabilities base.* A shared education route would also enable staff to move more flexibly between different roles across the sector.

Summary of recommendations

1. Raise awareness of career opportunities in Digital Health and Care among career advisers, parents, school staff, students, education providers, perhaps via a strategic information campaign.
2. Strategic collaboration between the industry/employers and the education and skills system – to influence core curriculum, create education and career pathways, and embed placements and internships as part of degrees.
3. Improve the attractiveness of the Digital Health and Care sector by focusing on unique selling points (genuine challenge, values).
4. Raise awareness of the core skills and capabilities required in the sector, including soft skills, among education and training providers, employers, students etc.
5. Create a core education/training provision for the six categories, allowing for opportunities for specialisation later on in the degree, and for a more flexible movement between job categories.
6. Create early career opportunities for translational job categories.
7. Create CPD opportunities to upskill/reskill existing staff and attract new talent to the sector – young people as well as experienced staff (incl. career changers) from other parts of the economy.

1 About this report

This report has been produced in partnership with Skills Development Scotland (SDS), and it constitutes a continuation to the 'Review and Analysis of the Digital Health Sector and Skills for Scotland' published in 2018. One of the many recommendations of that report was to develop better defined career pathways into Digital Health and Care. This study has sought to address this through examining six occupational categories in most urgent need of skilled staff: Software Developers, Product Owners, Implementation Facilitators, Knowledge Engineers, Health Data Analysts and Cyber Security Specialists.

Based on desk research and in-depth qualitative interviews with a minimum of four representatives from each category, the study probed into the nature of these roles, the required skills and capabilities of people employed in them, as well as the education and career pathways taken to enter these roles, and the current educational pathways that are available to those seeking to enter into these roles.

While the interviewee sample is limited, the aggregated data is sufficient enough to highlight the main issues affecting the sector's workforce in these categories in Scotland and deepen the knowledge and understanding gained from our previous research, and the desk-research carried out for this study.

The main purpose of this study is to highlight issues underlying the lack of clear career pathways and offer pointers for organisations involved in planning the education and training provision for the (Digital) Health and Care sector in Scotland.

The occupational categories in the study range from well-established to the emerging ones. Some categories already have recognised educational pathways (such as Software Developers), while others do not (such as Knowledge Engineers). However, the study uncovered a more fundamental issue than the lack of clear existing education and career pathways into Digital Health and Care Sector: *a general lack of awareness that these career opportunities exist*. This translates into a lack of well-defined education and career pathways.

Secondly, the study identified an important characteristic among the most urgently required occupational categories in Digital Health and Care: *many of these roles are positioned at the interface of humans and technologies, translating data, knowledge and information between them*. Recognising these new types of translational roles is crucial in supporting the development and implementation of digital solutions as part of the transformation affecting Health and care system.

The study also showed the how *the distinctly human soft skills* – skills and capabilities not replicable by technology – *are increasing in importance* across these roles. Furthermore, the study found that the vast majority of the skills and capabilities identified in the data are shared between the categories. This creates valuable *opportunities to consider common approaches to education, development and career planning* for these staff groups. This could include undertaking a shared period of

training which focuses on core skills and knowledge before branching out into different specialisms at a later stage. A shared basic training between the categories would also open the prospect of helping staff to move more flexibly between the different roles, addressing the growing pressure for having skilled digital health and care staff available within the system.

The report unfolds as follows: chapter 1 provides an introduction and background to the report, outlining the occupational categories, as well as the research and analysis methodology used in the study. In Chapter 2, the drivers behind the expanding Digital Health and Care sector are discussed, followed by an introduction to roles that are either stable, emerging or disappearing from the sector. Chapter 3 outlines the new skills framework developed for the purposes of this study, the “21st Century Skills Plus” and introduces the Skills Heat Map, which illustrates the skills and capabilities required by each occupational category based on the data. For full discussion on how this framework was arrived at, please, see Appendix 3. Chapter 3 also discusses the different occupational categories in relation to each other and the Heat Map. Chapter 4 presents a description of each occupational category in more detail, including the different career pathway maps for each interviewee, and presents an analysis of the data. Detailed skills and capability tables for each occupational category are available in Appendix 5. Chapter 5 discusses the findings and recommendations, which are presented in a summary table in Chapter 6.

1.1 Introduction and background

The Digital Health and Care sector¹ – born out of the conjunction of health and care services, mobile health and information and communications technology (ICT) - is one of the fastest growing economic sectors globally, with an ever-growing need for skilled staff ^[1]. A recognised factor restricting economic growth in the Digital Health and Care sector in Scotland is the lack of suitably skilled workers. Across the economy, skills shortages cost the UK economy an additional £2bn annually in higher salaries, recruitment costs and temporary staffing bills ^[2].

Along with the rest of the economy, the health and care workforce is required to be more agile and flexible to deal with the accelerating pace of technological change: digitisation and automation of services, the arrival of artificial intelligence (AI), cloud-computing, Internet of Things (IoT), Big Data, machine learning and more. This, in

¹ A distinction is made between *the general Health and Care sector*, and *the Digital Health and Care sector*. The latter denotes “*businesses and public sector employers, who specialise in a field, or offer job roles, which combine IT know-how with healthcare expertise*” ^[1]. A further distinction was made between “*companies that produce, provide and service digital health solutions*” (*ibid.*) on the one hand, and “*health and care service providers that utilize and implement digital healthcare solutions and tools in the delivery of their services*” (*ibid.*) on the other.

combination with the ageing population and their increasingly varied health and care needs, are changing the nature of work and the skills requirements within the sector. It will also increase the need for staff for the specialist digital health and care occupational categories discussed in this study. Within Scotland, a major issue affecting the digital health and care workforce in the NHS is that the aforementioned categories are not currently recognised as distinct occupational categories within the organisation but regarded, often misleadingly, as part of the “IT-staff”. A recent study by the Digital Health and Care Institute (2019), produced in parallel with this report, examines the specialist data, information and knowledge workforce at the NHS, and their role as the driving force of Digital Health and Care^[3]. There is a partial overlap between the occupational categories examined in our study and the specialist information, data and knowledge workforce, such as the Health Data Analysts. However, the logic of these two studies is different with this study examining occupational categories related to the process of planning and designing digital health and care systems through to their implementation and use. The findings and recommendations from both studies complement and support each other (please, see DHI 2019, Ch 1.3. for recommendations for development).

The World Economic Forum (WEF) (2018) forecasts an increasing skills instability in the next 4-5 years: the vast majority of employers across all industries expect the skills required to perform most jobs to have shifted significantly by 2022 ^[4]. They also anticipate 54% of employees to require some form of reskilling or upskilling. This issue affects the Health and Care sector as well. NESTA (2018) has called for the creation of an informed labour market, where education providers, workers, students, employers and policy makers know how skills are changing, and are able to respond to these changes to counter skills mismatches and shortages ^[5]. The recently published Topol Review calls for the NHS to recruit new talent and to establish new career pathways ^[6]. It is within this context that our report has been written.

1.2 Occupational categories

For the purposes of this report, the term “occupational category” has been used when referring to the groups of jobs or careers under scrutiny. According to A Dictionary of Sociology (1998), an “occupation” can be understood as a broader concept than a “job”, denoting a group of similar jobs identified with a common occupational title, or “*whose main tasks and duties are characterised by a high degree of similarity (skill specialisation)*” ^[7, 8]. Jobs and occupations can be described in terms of tasks, skills, responsibilities, earnings, entry qualifications and prestige ^[7].

Given the continuous social, economic and technological changes affecting the landscape of work, we discovered that there were a lot of similar jobs with no strictly standardised job titles. Hence, it was more purposeful to talk about “Occupational

categories”, which enabled a more sensible way to include and exclude interviewees in the study.

The six occupational categories investigated in this report are:

1. Software developer
2. Product Owner
3. Implementation Facilitator
4. Knowledge Engineer
5. Health Data Analyst
6. Cyber Security specialist

The selection of the categories was based on the findings of the previous DHI report and discussions held with domain experts ^[1]. The categories are described in more detail in Chapter 4, followed by the analysis of the interview data.

While the research concerns six occupational categories, the final analysis focusses on a total of eight categories. Research showed it was more meaningful to divide the Cyber Security Specialists into more dedicated categories: Cyber Security Architects, Cyber Security Administrators and Cyber Security Consultants. These categories are based on interviews held with Cyber Security Specialists, and are described, along with all the other ones, in Chapter 4.

1.3 Research methodology and analysis

The basis of this report lies on extensive desk-research, where the changing landscape of skills requirements, the nature of the six selected occupations, and different frameworks for classifying skills and capabilities were investigated. In addition, 26 digital health and care professionals participated in semi-structured, in-depth qualitative interviews, sharing their education and career histories and their knowledge of the sector and its skills requirements.

The participants’ career histories were visualised as timelines as part of the interviews. The interview schedule, the participant information sheet and the ethical consent form are available in Appendix 1; the career maps in Appendix 2. All the interviews were digitally recorded, and subsequently transcribed and analysed by members of the DHI’s research team.

The interviewees came from 17 organisations across:

- The NHS (incl. NHS24, NSS, NES, ISD);
- Scottish Government;
- Academia;
- Private sector;
- Third sector.

The seniority of the representatives varied from early career employees (2 years into their career) to persons in senior positions. Over 75% of the interviewees came from the Public sector; the gender division of the interviewees was 58% male, 42% female. Figure 1.1 below shows the gender division per category:

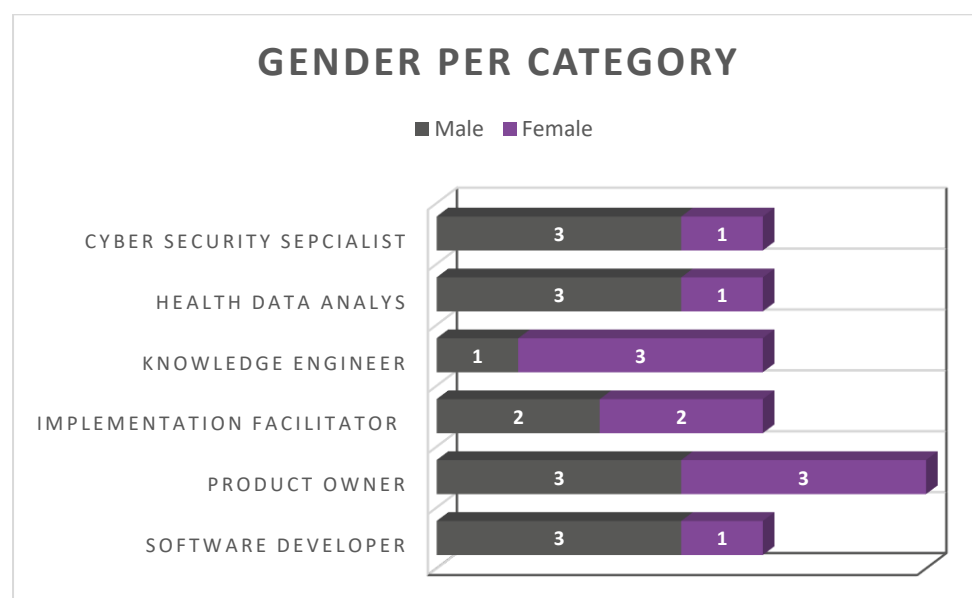


Figure 1.1: Gender per category

The job role descriptions and skills and capability requirements were extracted from the interviews and arranged into matrices. The data was first compared within the occupational category in question to identify similarities and differences between the roles and people's education and career pathways into their current roles.

Secondly, the skills requirements for each category were collated, arranged thematically, compared, and aligned with the updated 21st Century Skills Plus framework (for a full discussion, please see Appendix 3), which created a skills and capabilities requirement tables for each occupational category (available in Appendix 5). Finally, the tables were translated into the 21st Century Skills Plus Heat Map representing the findings of the data (for the full map, please, see Appendix 6). This allowed for an overall comparison of skills and capability requirements for each occupational category.

A "Development Workshop" was also arranged and participants were invited to examine and comment on the early findings of the study, and to offer recommendations for how best to encourage more people to choose digital health and care as an education and career option. The 20 invitees comprised stakeholders from the Scottish Government, the education sector, third sector, Health and Care and the private sector. The feedback from the workshop has contributed to the final analysis of data and recommendations.

2 The expansion of the Digital Health and Care sector

The Digital Health and Care sector² is an emerging growth area within the wider Health and Care sector. According to World Economic Forum (2018), the Health and Care sector shares a number of market drivers with the ICT sector, which can jointly be seen as pushing forward the growth of the Digital Health and Care sector ^[4]:

1. Advances in AI;
2. Expansion and affluence in developing economies;
3. Increasing adoption of new tech;
4. Increasing availability of Big Data;
5. Advances in mobile internet; and
6. Expansion of education.

The drivers are listed the table below, with joint market drivers highlighted in colour:

Drivers affecting Health and Care	Drivers affecting ICT
1. Increasingly aging societies	1. Increasing adoption of new tech
2. Advances in AI	2. Advances in cloud tech
3. Expansion and affluence in developing economies	3. Increasing availability of Big Data
4. Expansion of the middle class	4. Advances in mobile internet
5. Increasing adoption of new tech	5. Advances in computing power
6. Increasing availability of Big Data	6. Advances in AI
7. Shifts in global macro-economic growth	7. Advances in devices bridging the human-machine divide
8. Shifts in national economic growth	8. Expansion of affluence in developing economies
9. Advances in mobile internet	9. Expansion of education
10. Expansion of Education	10. Advances in new energy supplies and tech

Table 2.1: Shared drivers in the Health and Care and ICT sectors. Data source: World Economic Forum 2018 ^[4]

The Digital Health and Care sector is diverse and interdisciplinary with a wide variety of occupations and job roles³. These range from careers requiring higher level computing knowledge (such as Software Development and Software Engineering) to roles, which entail working in the space between technology and humans (such as

² An updated market analysis of the Digital Health and Care sector is in Appendix 4.

³ For more information, see Rimpiläinen et al., 2018 ^[1].

Product Owner, Knowledge Engineer or Implementation Facilitator) to human-facing roles (such as a Cyber Security advisor among health and care staff). There is a specific lack of personnel who possesses a combination of ICT proficiency and an understanding of the Health and Care domain ^[1].

Software Engineers and Data Analysts were the fastest growing professional roles according to hiring trends in 2013-17 both within the Healthcare and the ICT sectors ^[4]. Care giving, and roles requiring technology and computational thinking were listed among the top 5 industries by an earlier survey by the World Economic Forum carried out in 2016.

Looking at the broader Digital Tech sector, TechCity (2016) report categorised the existing job roles into three types ^[9]:

1. Natives: Digital jobs in digital technology industries, e.g. a front-end developer in a software company (22% of the workforce);
2. Supporters: Non-digital jobs in digital technology industries, e.g. a market manager in a data analytics company (37% of the workforce);
3. Transformers: Digital jobs in traditional industries (e.g. a data scientist in the public sector) (41% of the workforce).

With the emergence and deepening of digital in the Health and Care sector, our analysis shows that a new group of job roles can be seen emerging. This entails people working at the interface of technologies, *translating* data, information, intelligence or knowledge for use between computers and humans. We call this new category:

4. Translators: jobs at the interface of digital technologies and humans.

The occupational categories falling into this group are:

- **Product Owners** - translate users' needs into technical terms for Software Developers and translate the capabilities and limitations of software into lay terms for users to understand.
- **Health Data analysts** - translate numerical data into information and intelligence to support health and care decisions. This involves using statistical techniques, and increasingly also artificial intelligence techniques such as machine learning.
- **Knowledge Engineers** - translate explicit and tacit knowledge into tools and products that support decision-makers in health and care. Following industry trends, these roles are increasingly focusing on creating models and algorithms based on validated knowledge to inform decision-making.

- **Implementation Facilitators** – work with health and care staff and organisational processes to translate digital innovations into routine use in health and care services

These roles will be crucial for delivering the digital transformation of health and care services. This category finds support from the WEF 2018 Future of Jobs survey, which lists examples of job roles in three categories: roles that remain stable, new roles and roles that are on their way out across all industries (see table 2.2 below) ^[4]. Please, note that roles marked with * appear across multiple columns. This denotes that there may be a growing demand for that role in one industry, while the demand is declining in another.

Stable Roles	New Roles	Redundant Roles
Managing Directors and Chief Executives General and Operations Managers* Software and Applications Developers and Analysts* Sales and Marketing Professionals* Sales Representatives, Wholesale and Scientific Products Human Resources Specialists Financial and Investment Advisers Database and Network Professionals Supply Chain and Logistics Specialists Risk Management Specialists Information Security Analysts* Management and Organisation Analysts* Electrotechnology Engineers Organisational Development Specialists* University and higher education Teachers Compliance Officers Robotics Specialists and Engineers	Data Analysts and Scientists* AI and Machine Learning Specialists General and Operations Managers* Big Data Specialists Digital Transformation Specialists Sales and Marketing Professionals* New Technology Specialists Organisational Development Specialists* Software and Applications Developers and Analysts* Information Technology Services Process Automation Specialists Innovation Professionals Information Security Analysts* Ecommerce and Social Media Specialists User Experience and Human-Machine Interaction Designers Training and Development Specialists Robotics Specialists and Engineers People and Culture Specialists Client Information and Customer Service Workers* Service and Solution Designers Digital Marketing and Strategy Specialists	Data Entry Clerks Accounting, Bookkeeping and Payroll Clerks Administrative and Executive Secretaries Assembly and Factory Workers Client Information and Customer Service Workers* Business Services and Administration Managers Accountants and Auditors Material-Recording and Stock-Keeping Clerks General and Operations Managers* Postal Services Clerks Mechanics and Machinery Repairers Telemarketers Electronics and Telecommunications Installers and Repairers Bank Tellers and Related Clerks Car, Van and Motorcycle Drivers Sales and Purchasing Agents and Brokers Statistical, Finance and Insurance Clerks Lawyers

Table 2.2. Stable, New and Redundant job roles. Adapted from Future of Jobs survey, World Economic Forum 2018 ^[4].

Compared to the six occupational categories discussed in this study, a number of obvious similarities are identifiable amongst the stable and the new roles as identified by the WEF ^[4]. The table below presents this comparison:

Future of Jobs survey ^[4] (* denotes both stable and emerging category; no star denotes emerging category)	This study
<ul style="list-style-type: none"> • Data Analysts and Scientists * • Big Data Specialists 	<ul style="list-style-type: none"> • Health data analyst
<ul style="list-style-type: none"> • Digital Transformation specialists • Organisational Development Specialists* • New Technology Specialists 	<ul style="list-style-type: none"> • Implementation Facilitator
<ul style="list-style-type: none"> • Software and Applications Developers and Analysts* 	<ul style="list-style-type: none"> • Software developer
<ul style="list-style-type: none"> • AI and Machine learning specialists • Robotics Specialists and Engineers * 	<ul style="list-style-type: none"> • Knowledge engineers*
<ul style="list-style-type: none"> • Information security Analysts* • Database and network Professionals 	<ul style="list-style-type: none"> • Cyber security specialist
<ul style="list-style-type: none"> • User Experience and Human-Machine interaction Designers 	<ul style="list-style-type: none"> • Product Owner; Software developer
<ul style="list-style-type: none"> • Training and development specialists 	<ul style="list-style-type: none"> • Product Owner; Implementation facilitator

Table 2.3. Comparison of WEF 2018 job roles with the six OCs ^[4]

Roles that are “*significantly based on and enhanced by the use of technology*” will see a strong increase in demand by 2022 ^[4]. These include Data Analysts and Scientists, Software and Application Developers, and E-commerce and Social Media Specialists.

Demand will also grow for roles based on “*distinctly human skills*”, such as Training and Development roles, Organisational Development Specialists and Innovation Managers. The report further predicts accelerating demand for a range of emerging specialist roles “*related to understanding and leveraging the latest emerging technologies*”. These include AI and Machine Learning Specialists, Big Data Specialists, Process Automation Experts, Information Security Analysts, User Experience and Human-Machine Interaction Designers, Robotics Engineers and Blockchain Specialists ^[4].

With regards to declining roles, those that had an alignment with our six occupational categories were Clerks performing Statistical or Data Entry tasks. These tasks are often part of early career Data Analysts' workloads and may become heavily automated in the future.

The translational jobs within the Digital Tech industry align with the specialist roles related to understanding and leveraging the latest technologies. Defining this overarching job category could help facilitate collaboration, skills transfer, and development of career pathways based on shared capabilities.

3 “21st Century Skills Plus”

For the purposes of this report, an extensive review of different skills categorisations was carried out. For a full discussion, please refer to Appendix 3. This work, in conjunction with the analysis of data and the evidence collated for this research, resulted in the creation of an updated version of the well-established 21st Century Skills framework (used e.g. by Silva 2009; Binkley et al. 2014, Grey 2016; Desjardins 2018) ^[10-13]. **We have named this categorisation 21st Century Skills Plus, and it is intended to better reflect the fast pace of change in society and the work landscape, promoting competencies and capabilities employees need to thrive in the information age.** The framework is an amalgamation of the 21st Century skills framework (“not new, only newly important” - Silva 2009, 631) with updates from the World Economic Forum Top 10 skills predictions for 2022, and skills and capabilities that emerged from our data, as well as the feedback from the participants in the Development Workshop ^[4, 10 & 14].

The 21st Century Skills Plus framework includes the following skills ^[14]:

1. Communication
2. Active learning and learning strategies
3. Advanced Information literacy
4. Advanced ICT Literacy
5. Organisational skills (productivity & accountability, initiative)
6. Critical thinking, complex problem-solving & analysis
7. Creativity, originality, inventiveness and ideation
8. Collaboration
9. Project/ programme Management skills
10. Design
11. Systems analysis and evaluation and Quality improvement
12. Technical IT skills
13. Coding / programming languages
14. Emotional intelligence

In addition, the following skills emerged from our data as relevant for the six (eight⁴) occupational categories examined in our study:

15. Domain specialism
16. End user engagement
17. Cyber security (knowledge and skills)
18. Business skills & awareness
19. Research, data analysis, analytical skills
20. Facilitation skills
21. Change management
22. Training skills

This Heat Map illustrates the skills, capability and knowledge for each occupational category.

Key to the Heat Map:

- Red – important skill;
- Maroon – crucial skill for the role;
- Orange - employees require at least a working knowledge of the skill;
- Blue – role requires a basic understanding/basic skill;
- Grey - the skill category is not relevant for the role in question.

The first 14 skills marked in purple constitute the 21st Century Plus skill list; the deep pink indicates skills that have emerged from our data set.

⁴ Including the separate Cyber security specialist categories – Consultant, Administrator and Architect.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Skills, capability, knowledge / Position	Communication	Active learning & learning strategies	Advanced Information literacy	Advanced ICT Literacy	Org. skills (productivity & accountability)	Critical thinking, complex problem-solving & analysis	Creativity, originality and initiative	Project/ programme Mgt skills	Collaboration	Design	Systems analysis and evaluation + Qual imp	Technical IT skill	Coding / programming languages	Emotional intelligence	Domain specialism (knowl of H&C)	End user engagement	Cyber security (knowledge and skills; specialist)	Business skills & Awareness	Research, Data Analysis, Analytical skill	Facilitation skills	Change management	Training skill
Software developer / engineer	I	I	I	I	I	I	I	I	I	C	I	C	C	I	B	C	I	W	NA	NA	NA	NA
Product Owner	C	I	I	I	I	I	I	I	I	W	W	B	B	C	C	C	W	I	NA	I	W	NA
Implementation Facilitator	C	I	I	I	I	C	I	I	I	W	C	B	B	C	C	C	W	W	I	C	C	I
Knowledge Engineer	C	I	C	I	I	C	I	I	I	I	W	I	I	C	C	C	W	W	C	I	C	W
Health Data Analyst	I	I	I	I	I	I	W	I	W	I	B	C	C	W	W	W	W	W	C	NA	NA	NA
Cyber security architect	I	C	I	I	I	I	I	I	I	C	C	C	C	W	W	W	C	W	I	NA	NA	NA
Cyber security "administrator"	I	C	I	I	I	I	I	B	W	I	I	C	I	W	W	B	C	B	NA	NA	NA	NA
Cyber security "consultant"	C	C	I	I	I	W	B	B	W	NA	NA	NA	NA	I	C	I	C	B	NA	NA	NA	I
	Crucial	C		Important	I		Requires working knowledge	W		Basic understanding	B		Not relevant / Not mentioned in data	NA			21st Century / WEF 2018			Emerged from our data		

Table 3.1: Heat Map of skills and capabilities. A full-size map is in Appendix 6.

3.1 Skills categories on the Heat Map

The skills in this framework are listed in the order of importance as they appeared in the data (see the skills Heat Map, which is our interpretation of the data). The WEF (2018) framework offered a vocabulary to identify capabilities that are not mentioned in the 21st Century framework, such as “Active learning and learning strategies”, “Emotional intelligence” or “Technology design and programming” [4]. However, given that not every occupational category requires “Technology design and programming”, the category is separated into “Design”, “Coding and programming” and “Technical IT skills”. The less technical roles require “Advanced IT literacy”, an understanding of what the technology does and why it does it, but not necessarily *how* it does it. Similarly, they may need to understand what good design looks like, but not how to design something.

The Four C’s - Critical thinking, Creativity, Collaboration and Communication - of the 21st Century skills feature prominently in the table, too. “Communication” emerged at the top as the most important capability of all. “Critical thinking, complex problem-solving and analysis” is an amalgamation of the three WEF 2018 capabilities “Critical thinking and analysis”, “Complex problem-solving” and “Reasoning, problem-solving and ideation”, which were not sufficiently different from each other to merit a separate category each [4]. “Ideation” in our analysis has been moved to the same category as “Creativity”: “Creativity, originality, inventiveness and ideation”.

“Collaboration” and “Leadership and social influence” are both important capabilities, but very dependent on the context of the individual employee and their seniority in the organisation. For that reason, we have left the leadership category out of the Heat Map.

“Emotional Intelligence” replaces “Social and cross-cultural interaction” and “Active listening”, effectively covering the same domain [4 & 11]. “Domain specialism”, i.e. the knowledge of the Health and Care sector, went almost hand in hand with emotional intelligence, forming a stark contrast to those categories that need technical IT- and programming skills.

“Organisational skills” emerged important for each occupational category, going often together in importance with “Project management skills”. Depending on context, project management could mean broader professional project management capabilities, or just the person’s personal ability to manage a project they were working on. When the former is the case, this is detailed in the skills table for the occupational category in question (Appendix 5).

The skills and capabilities detailed from number 14 onwards emerged from our data. These include, e.g., “Facilitation skills” or “Change Management” required specifically of Implementation Facilitators, or “Training skills” required of Cyber Security Consultants.

Overall, the level at which each skills category is required by each occupational category is context and seniority dependent, which is where the SFIA framework methodology is useful (please, see Appendix 4) ^[15]. However, our data set is not large enough to fill the seven levels of that framework.

3.2 Occupational categories on the Heat Map

The skills Heat Map visualizes an interesting divide between the occupational categories in the study. The division emerges between roles that require technical IT and coding skills versus categories that emphasize domain specialism and emotional intelligence.

The occupational categories that emphasize technical IT-skills and coding are:

- Software Developers
- Health Data Analysts (Translator category)
- Cyber Security Architects
- Cyber Security Admins

The occupational categories that emphasize domain knowledge and emotional intelligence are:

- Cyber Security Consultants
- Product Owners (Translator category)
- Implementation Facilitators (Translator category)

The only role cutting right across the divide is:

- Knowledge Engineer (Translator category)

	12	13	14	15	16	17
Skills, capability, knowledge / Position	Technical IT skill	Coding / programming languages	Emotional intelligence	Domain specialism (knowl of H&C)	End user engagement	Cyber security (knowledge and skills; specialist)
Cyber security "consultant"	NA	NA	I	C	I	C
Product Owner	B	B	C	C	C	W
Implementation Facilitator	B	B	C	C	C	W
Knowledge Engineer	I	I	C	C	C	W
Software developer / engineer	C	C	I	B	C	I
Health Data Analyst	C	C	W	W	W	W
Cyber security architect	C	C	W	W	W	C
Cyber security "administrator"	C	I	W	W	B	C

Table 3.2: The occupational categories divided into the more technical and more domain specialist types, Knowledge Engineers cutting across the divide. Order re-arranged to highlight the differences.

The most skills-intensive occupational categories that we examined were Knowledge Engineers (KE) and Implementation Facilitators (IF). Both the KEs and IFs require the widest range of skills, the highest number of specialist skills, with both needing more in-depth capabilities than other categories. These two categories share a bulk of their required skills with one another. The Heat Map shows that the primary difference between the two is the need for technical IT skills for KEs.

Interestingly, while appearing as a more sophisticated, senior role, IFs share many of the same capability requirements as Product Owners (POs), who often (but not always) are domain specialists, such as a nurse, engaged in a temporary project-related role as part of an Agile software development team. While both IF and PO roles entail working with the end-users of an emerging software (or other innovation in the case of an IF), the IFs need certain capabilities and more in-depth knowledge of the innovation than the POs, and their role is much broader in overall scope. This ranges from involvement in a project during its planning and design stages all the way through to its implementation and the training of the end-users). However, if the

Product Owner is a professional external to the organisation, some of their training requirements may be more akin to those of IFs.

Cyber Security Consultants (CScon) have a similar emphasis on skills and capabilities as POs and IFs but is the least skill-intensive of the three. It is envisaged that a suitable health and care practitioner could undertake some additional CPD-level training to become a Cyber Security Consultant/Support Officer for their peers. The main requirements for this role are domain specialism, excellent communication skills, knowledge and understanding of cyber security issues, including good cyber security practices and behaviours. As well as an ability to learn quickly and to continually update their skills.

The most skills-intensive category following Knowledge Engineers and Implementation Facilitators is the Cyber Security Architect (CSArc) category. This shares a bulk of its skills requirements not only with KEs, but also with Software Developers (SWD). The SWD and CS Architects often work in the same team when developing a software or a system. The main difference between the categories emerge in the intensity with which cyber security specialism is required.

KEs can also work as part of the same team with SWDs and CS Architects, but only if the software entails AI-components. The differences between the KEs and SWDs lie in the number of specialist skills required of KEs, including the depth of domain specialism and emotional intelligence their job necessitates.

While Health Data Analysts (HDAs) share a lot of the skills with KEs, their closest skills match is in fact with Cyber Security Administrators (CSAdmins), even if these jobs are quite different in scope. HDAs require expertise in research and data analysis in the support of decision making in health and care matters and to ensure that the hospital can provide the best care possible within its available budget. Whereas the main skill needed by CSAdmins is specialism in cyber security issues. They require this in order to act as the first line of defence for an IT-system, analysing and evaluating security threats, building cyber defences and solving problems. The main unifying factor may be the domain-agnostic nature of each role, as well as the systems/data oriented working patterns, which generally do not require as intensive contact with other people in comparison with SWDs, POs, KEs, IFs, and CS consultants.

3.2.1 Translational categories

The four translational categories include:

- Product Owners
- Health Data analysts
- Knowledge Engineers
- Implementation Facilitators

The skills required by these categories fall largely into the domain specialist and emotional intelligence sphere, while technical skills are important or crucial to Knowledge Engineers and Health Data Analysts. The translational roles also have the highest number of specialist roles, including research, facilitation, change management and training skills, all of which reflects the specific nature of these roles in the interface of computers and humans.

The Heat Map extract below (Table 3.3.) presents the skills and capabilities required by the translational occupations.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Skills, capability, knowledge / Position	Communication	Active learning & learning strategies	Advanced Information literacy	Advanced ICT Literacy	Org. skills (productivity & accountability)	Critical thinking, complex problem-solving & analysis	Creativity, originality and initiative	Project/ programme Mgt skills	Collaboration	Design	Systems analysis and evaluation + Qual imp	Technical IT skill	Coding / programming languages	Emotional intelligence	Domain specialism (knowl of H&C)	End user engagement	Cyber security (knowledge and skills; specialist)	Business skills & Awareness	Research, Data Analysis, Analytical skill	Facilitation skills	Change management	Training skills
Product Owner	C	I	I	I	I	I	I	I	I	W	W	B	B	C	C	C	W	I	NA	I	W	NA
Implementation Facilitator	C	I	I	I	I	C	I	I	I	W	C	B	B	C	C	C	W	W	I	C	C	I
Knowledge Engineer	C	I	C	I	I	C	I	I	I	I	W	I	I	C	C	C	W	W	C	I	C	W
Health Data Analyst	I	I	I	I	I	I	W	I	W	I	B	C	C	W	W	W	W	W	C	NA	NA	NA

Table 3.3: image of the Heat Map showing the translational roles.

3.2.2 Core skills

With the exception of their specialist skills, most occupational categories share the bulk of skills requirements albeit with varying intensity. Skills shared by all categories deemed as “important” or “crucial” (with a few exceptions) include skills 1-9:

1. Communication
2. Active learning and learning strategies
3. Advanced Information literacy
4. Advanced ICT Literacy
5. Organisational skills (productivity & accountability, initiative)
6. Critical thinking, complex problem-solving & analysis
7. Creativity, originality, inventiveness and ideation
8. Project/ programme Management skills
9. Collaboration

	1	2	3	4	5	6	7	8	9
Skills, capability, knowledge / Position	Communication	Active learning & learning strategies	Advanced Information literacy	Advanced ICT Literacy	Org. skills (productivity & accountability)	Critical thinking, complex problem-solving & analysis	Creativity, originality and initiative	Project/ programme Mgt skills	Collaboration
Cyber security "consultant"	C	C	I	I	I	W	B	B	W
Product Owner	C	I	I	I	I	I	I	I	I
Implementation Facilitator	C	I	I	I	I	C	I	I	I
Knowledge Engineer	C	I	C	I	I	C	I	I	I
Software developer / engineer	I	I	I	I	I	I	I	I	I
Health Data Analyst	I	I	I	I	I	I	W	I	W
Cyber security architect	I	C	I	I	I	I	I	I	I
Cyber security "administrator"	I	C	I	I	I	I	I	B	W

Table 3.4: Skills 1-9, 21st Century Skills Plus Heat Map

The most important skill for all categories is *Communication*, deemed crucial for Cyber Security Consultants, Product Owners, Implementation Facilitators and Knowledge Engineers. Interestingly, that was not included in the trending skills for 2022 [4].

Active learning and learning strategies was a skill introduced by the World Economic Forum's Future Jobs Survey (2018), and it was seen as trending on the second place in importance in Skills for 2022 [4]. The ability to learn new things quickly was named as an important capability for all categories, and deemed crucial for Cyber

Security workers, who need to be able to continually keep abreast of a fast-evolving cyber landscape.

Advanced information literacy, Advanced ICT literacy as well as *Organisational skills relating to productivity and accountability* are important across the board. With *Advanced information literacy* being crucial for KEs and *Critical thinking, complex problem-solving and analysis* being a crucial capability for Implementation Facilitators and Knowledge Engineers. The importance of organisational skills was seemingly diminishing, with related skills falling away from the top 10 for skills trending in 2022. While *complex problem-solving or analysis* might not be core capabilities required of Cyber Security Consultants, the very nature of their role (assessing cyber security needs of their colleagues and of their work environment) necessitates them to have the ability think critically.

Two of the four important C's of the 21st Century framework, *Creativity* and *Collaboration* have more fluctuating importance amongst these occupational categories than Communication and Critical thinking. *Creativity, originality and initiative* featured at 3rd place in the WEF 2022 list, having risen by two places since the 2018 trend list ^[4]. The nature of the job and the context of work does impact how collaboratively or creatively a person can or needs to work. CS Consultant and Health Data Analyst jobs were deemed to need less creative ability. Similarly, these two categories, in addition to CS administrators, did not require collaborative skills to the same degree as other categories. Project Management skills were important to every other category except CS administrators and CS consultants.

3.2.3 Skills showing the division between technical and domain specialist jobs

The next set of skills in the Heat Map have more variance in terms of importance for the occupational categories. These also separate the different occupational categories in relation to their need for technical ability versus domain specialism.

10. Design
11. Systems analysis and evaluation and Quality improvement
12. Technical IT skills
13. Coding / programming languages
14. Emotional intelligence
15. Domain specialism
16. End user engagement
17. Cyber security (knowledge and skills)
18. Business skills & Awareness

	10	11	12	13	14	15	16	17	18
Skills, capability, knowledge / Position	Design	Systems analysis and evaluation + Qual imp	Technical IT skill	Coding / programming languages	Emotional intelligence	Domain specialism (knowl of H&C)	End user engagement	Cyber security (knowledge and skills; specialist)	Business skills & Awareness
Cyber security "consultant"	NA	NA	NA	NA	I	C	I	C	B
Product Owner	W	W	B	B	C	C	C	W	I
Implementation Facilitator	W	C	B	B	C	C	C	W	W
Knowledge Engineer	I	W	I	I	C	C	C	W	W
Software developer / engineer	C	I	C	C	I	B	C	I	W
Health Data Analyst	I	B	C	C	W	W	W	W	W
Cyber security architect	C	C	C	C	W	W	W	C	W
Cyber security "administrator"	I	I	C	I	W	W	B	C	B

Table 3.5: Skills 10-18, 21st Century Skills Plus Heat Map

Technology Design was mentioned as a new core capability for 2022 along with *Coding and Programming* by the 2018 World Economic Forum [4]. This skills category is separated into two separate columns in the analysis, as it was relevant for the occupational categories. *Systems analysis and evaluation* was also a new category in place 10 in the WEF 2018 list of trending skills. *Emotional intelligence* featured at 8th place [4]. The rest of the skills presented here emerged from our research data.

CS consultants do not require any technical ability as part of this role, while Product Owners require at least a basic understanding or working knowledge of *Design*, *Systems analysis and evaluation*, *Technical IT skills* or *Coding*. On the other hand, *Domain specialism*, *End user engagement* and *Emotional intelligence* are crucial or important for CS consultants, Product Owners, Implementation Facilitators, Knowledge Engineers and Software Developers. *Design*, *Technical IT skills* and *Programming skills* are important or crucial for KEs, SWDs, HDAs, CS architects and CS admins. *Business skills and awareness* are something every category requires at least at a basic level, as is the case with cyber security, which naturally is of crucial importance for all CS specialists.

3.2.4 Specialist skills

Skills from 14 to 22⁵ in our categorisation are those that emerged from the data. 19-22 really differentiate the various specialist orientations of the occupational categories.

- 19. Research, Data analysis, Analytical skill
- 20. Facilitation skills
- 21. Change management
- 22. Training skills

	19	20	21	22
Skills, capability, knowledge / Position	Research, Data Analysis, Analytical skill	Facilitation skills	Change management	Training skills
Cyber security "consultant"	NA	NA	NA	I
Product Owner	NA	I	W	NA
Implementation Facilitator	I	C	C	I
Knowledge Engineer	C	I	C	W
Software developer / engineer	NA	NA	NA	NA
Health Data Analyst	C	NA	NA	NA
Cyber security architect	I	NA	NA	NA
Cyber security "administrator"	NA	NA	NA	NA

Table 3.6: Specialist skills 19-22, 21st Century skills+ Heat Map

⁵ We have left out the assessment of skill 23 - Leadership and social influence, as this is very much dependent on seniority of the employee, and our model does not account for these nuances.

These skills show the specialist capabilities required by each occupational category. The more (bigger number of) grey squares there is in the column, the more specialised the skills presented is.

Research and Data analytic skills are crucial to the research-intensive roles of KEs, HDAs, and important to IFs and CS architects. The ability to do research is not relevant for the rest of the categories.

Facilitation skills are crucial to IFs along with *Change management skills*. These can also be relevant to POs and KEs. Finally, *Training skills* are important for CS consultants and IFs, as well as KEs but with less intensity.

4 The six occupational categories

This chapter presents a description of each of the eight⁶ occupational categories with the analysis of data. Detailed skills tables for each category are available in Appendix 5.

4.1 Software developers / engineers

4.1.1 Description

Job titles and descriptions in IT are not standardised. As well as a software developer or engineer, this job role might be referred to as a systems / software / database / computer / web programmer / engineer or developer. The job title is usually dependent upon the organisation a Software Developer works for, and whether they work as part of a larger team of IT specialists, or if they work in a one-man company ^[17].

Software development / engineering has been defined as “*the process of analysing user needs and designing, constructing, and testing end user applications that will satisfy these needs through the use of software programming languages. It is the application of engineering principles to software development. In contrast to simple programming, software engineering is used for larger and more complex software systems, which are used as critical systems for businesses and organizations.*” ^[16]

Software engineer jobs combine highly complex, technical work with computer science and mathematics ^[18]. The work tasks vary according to the type of organisation and the size of employer, but typically involve ^[18]:

- Analysing user requirements;
- Writing and testing code, refining and rewriting it as necessary;
- Researching, designing and writing new software programs;
- Evaluating the software and systems that make computers and hardware work;
- Developing existing programs by analysing and identifying areas for modification;
- Integrating existing software products and getting incompatible platforms to work together;
- Creating technical specifications;
- Writing systems to control the scheduling of jobs or to control the access allowed to users or remote systems;
- Writing operational documentation with technical authors;
- Maintaining systems by monitoring and correcting software defects;

⁶ Eight categories, when Cyber Security is divided into three specialisms.

- Working closely with other staff, such as project managers, graphic artists, UX designers, other developers, systems analysts and sales and marketing professionals;
- Consulting clients and colleagues concerning the maintenance and performance of software systems with a view to writing or modifying current operating systems;
- Investigating new technologies;
- Continually updating technical knowledge and skills by attending in-house and external courses, reading manuals and accessing new applications.

4.1.2 Findings: Software Developers

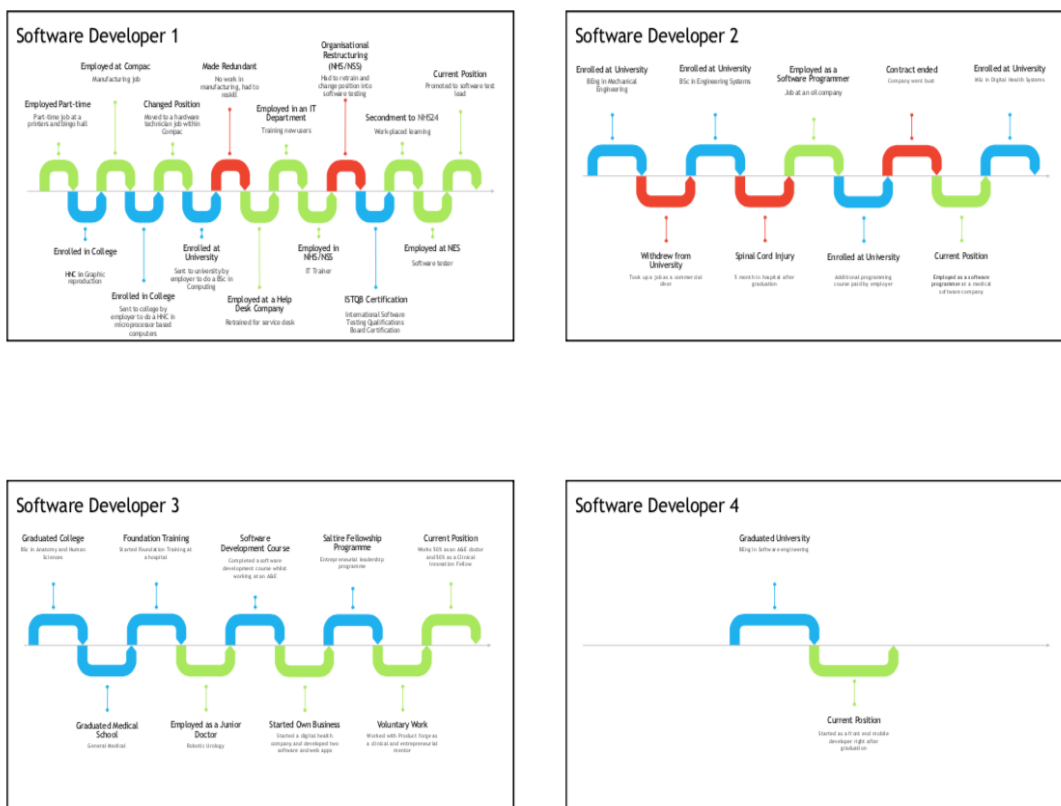


Image 4.1: Outline of Software developer career pathways. Full size maps are available in Appendix 2. Blue indicates education/training; green employment; red a turning point or life event.

- The Software Developer cohort has varied educational backgrounds, but all have completed some form of computing related training or education, ranging from completing college qualifications and university degrees in different but often related subjects to attending intensive programming courses and doing learning on the job.
- Only one person – the youngest of the cohort - had chosen to move directly into a job in the Digital Health sector after graduating as a Software Engineer.

- Three out of four research participants have moved into Digital Health at a later stage in their careers.
 - That reflects the fact that digital health and care is an emerging field, and that this career option has not existed for very long.
- Most of the representatives have continued their professional development with subsequent courses, certifications, on the job learning and/or further education.
- On the job learning was mentioned as an important aspect of working in digital health related jobs.

4.1.3 How skills are learned

Please, see the full skills and capability table for Software Developer in Appendix 5a.

- Most universities and all colleges in Scotland provide well-established Software Developer and Software Engineering qualifications at undergraduate and postgraduate level.
- A few Scottish universities also offer special MSc courses that prepare people for work specifically in digital health and care. The number of these courses is on the increase.
- On the job learning was mentioned as an important aspect of working in digital health related jobs: most of the representatives have continued their professional development with subsequent courses, certifications, on the job learning and/or further education.
- While the university or college degrees equip the students with basic abilities required in software development, the skills required to actually perform the job are learned or further developed on the job. This is especially the case with the so called soft or 21st century skills.

As so many well-established educational routes already exist for those wishing to become Software Developers, it emerged as a more meaningful question to ask *how to attract more people to work in the Digital Health and Care sector.*

The consultees made the following recommendations:

Internal routes:

- Redeployment and retraining of existing staff.
 - At the NHS or care organisations this could mean offering different and more flexible career progression options and making career-switching easier.
- Better utilisation of people returning to work.

- For example, offering re-training or on the job training and more flexible working patterns for people returning from parental leave or lengthy sickness leave.

External routes:

- Establishing Digital Fellowships for clinicians and medical professionals in collaboration with the employer and an education provider to offer the time to pursue a different career pathway into digital health;
- Including elective software development modules in clinical and nursing education to generate interest from some medical professionals in digital health/software development during their education;
- Making accredited industrial placements available for Software Developers in health and care;
- Improving the take up of work-based learning routes such as Modern Apprenticeships (MAs) and Graduate Apprenticeships (GAs) for Software Developers;
- Improve the effectiveness of existing programmes; include optional modules in basics in health and care for Software Developers. Create new graduate programmes where necessary.

4.2 Product Owners

4.2.1 Description

Product Owner (PO) is a critical role in an Agile software development project. Working between the development team and the end users, the PO is responsible for gaining a clear understanding, a vision, of what features and functionalities the users require from the product. Ultimately, the PO translates the vision into actionable work – user stories - for the development team. Regardless of the type of the project, domain knowledge is one of the key requirements of a PO. The PO is in charge of setting, prioritising and evaluating the work generated by a software development team (or managing the product backlog - the full wish-list for the final product) - and signing off the developed features. The main concern of the PO is to ensure that the finished product is of the highest quality and functionality ^[19-23]. The PO role can also include aspects from other roles such as those of a business strategist, a customer liaison, a market analyst, a product designer and a project manager ^[24].

A Product Owner is often an IT professional, but the role can also be acquired by an end-user of the product, or someone with an in-depth understanding of the business domain in question.

According to Scrum, Product Owner responsibilities include ^[19, 20 & 22]:

- Stakeholder engagement to understand the client's and business's needs;

- Providing vision and direction to the Agile development team and stakeholders throughout the project and create requirements;
- Defining the features of the application (creating and maintaining the Backlog);
- Prioritizing features in the Backlog before Sprint;
- Participating in planning and running Sprint meetings;
- Clearly communicate the Business Requirements to the team;
- Adjusting the features and priority list as needed after each sprint or iteration;
- Accepting or rejecting work results;
- Keeping customers or users apprised of status and getting their feedback.

4.2.2 Findings: Product Owners



Image 4.2: Outline of Product Owner career pathways. Full size maps are available in Appendix 2. Blue indicates education/training; green employment; red a turning point or life event.

- Most Product Owners interviewed were working as part of Agile software development teams.
- In many cases, people had moved into the Product Owner role by way of extending their personal careers, on the basis of their intimate understanding of the domain in question.
- From the interviews completed, no critical educational route was identified into this role, which reflects the domain specific knowledge required in the role.
- The educational backgrounds were varied, ranging from those, who had worked their way up straight from school to those who have completed academic undergraduate and postgraduate qualifications.
- The PO disciplinary backgrounds varied as well, reflecting the domain specialist nature of the role.

4.2.3 How skills are learned

Please, see the full skills and capability table for Product Owner in Appendix 5b.

- There are no critical educational routes into this role.
 - Product Owner role is often taken on as part of, or an extension of another role. People are often recruited to this role internally.
 - A CPD type training and on-the-job-learning are seen as sufficient in many cases.
- Domain expertise and experience, or the ability to liaise effectively with domain experts, are crucial:
 - This is required for understanding the consequences of different decisions taken for the organisation and for the work that goes on.
- A robust understanding of *what* the technology does is essential for this role. (Knowing *how* it does it is not as critical.) ICT background, ICT-related work experience or receiving a certain level of technical training in software and technology development were seen as beneficial.
- Having training in project management was seen as high value for Product Owners. This was seen as giving structure to the potential Product Owners' softer skillsets.
- Training in Agile methodology was highlighted as high value certifications for the field. Projects utilising Agile methodology often offer training for prospective Product Owners.
- Challenges in the area include the difficulty in identifying suitable people to work as Product Owners and lack of funding to train staff to become Product Owners.

4.3 Implementation Facilitators

4.3.1 Description

Implementation facilitation has been defined as “a multi-faceted process of enabling and supporting individuals, groups and organizations in their efforts to adopt and incorporate clinical innovations into routine practices. Facilitation can incorporate or include many other implementation strategies, e.g., audit and feedback, education and training, and stakeholder engagement” [25]. At its simplest form, it is described as a process of interactive problem-solving that takes place in a context of a recognised need for improvement and supportive interpersonal relationships. However, it can also be a highly complex and multi-faceted strategy that incorporates a wide variety of implementation activities, including stakeholder identification and engagement throughout the whole organisation; identifying problems and matching solutions to them, offering local technical support, creating learning collaboratives, presenting evidence to support practice; marketing, staff training, citizen outreach and education, auditing and evaluation, engaging clinical champions and opinion leaders and fostering role models [25 & 26].

In the health and care context, an Implementation Facilitator (IF) supports the uptake and embedding of clinical, technological or service innovation as part of their day-to-day practice. In a local context they raise awareness of the innovation in question, identifying and overcoming barriers and leveraging strengths to foster the implementation of said innovation. The focus of the IF should be on how to prepare the workplace to embed a new technology or a service as part of their day-to-day practice with as little disruption as possible.

They help staff to prepare for upcoming changes and ensure that innovations are adapted to the local context, including processes and practices. IF's can draw upon methods and interventions used in Implementation Science to help others understand what types of changes are required in their environment, how to plan for and execute these changes, and how to overcome barriers to these. The emphasis of the process is often more on service design than on technology. Facilitators work with key stakeholders to choose innovations, adapt them to the local situation, but also select interventions for evaluation and tools to support the implementation.

Implementation facilitation is an evolving role, and comes into play before the innovation, e.g. a software, is fully delivered, engaging prospective users already in the design process. The IF works as part of a multi-sector and interdisciplinary team.

4.3.2 Findings: Implementation Facilitator

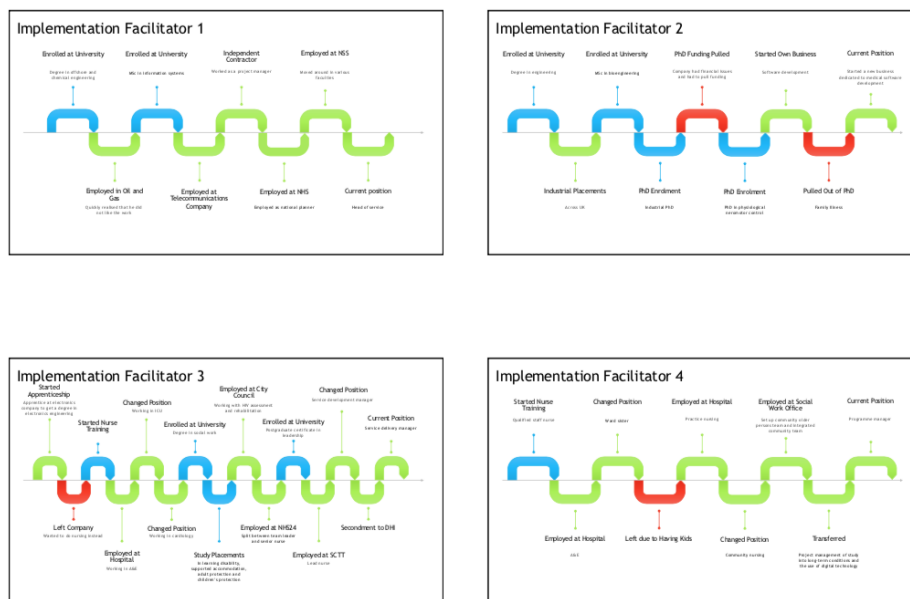


Image 4.3: Implementation Facilitator maps. Full size maps are available in Appendix 2. Blue indicates education/training; green employment; red a turning point or life event.

- The Implementation Facilitators who participated in the research had backgrounds in nursing or data sciences.
- No uniform educational background or career route into implementation facilitation could be identified among the representatives. However, all but one had gained postgraduate qualifications.
- All representatives had moved into implementation facilitation roles later on in their careers. This means they are senior experts in their respective fields. Having an in-depth knowledge of the domain in which the innovation is being implemented is seen as critical to carrying out the role successfully. Alternatively, having the ability to work in close collaboration with domain experts is vital.

4.3.3 How skills are learned

Please, see the full skills and capability table for Implementation Facilitator in Appendix 5c.

- The research indicates that there is no single qualification that would prepare a candidate for work as an Implementation Facilitator (IF).
- The IF role is very context-dependent, which will dictate the required domain expertise and core skills.
- IF role requires a lot of work experience from a range of roles, as well as an exceptional battery of soft skills.

- The required basic skills and capabilities have a lot of similarities with those required of Knowledge Engineers and Product Owners.

As the need for these professionals will grow in the Health and Care sector given the pace of digitisation of services, the question is: *how to begin to prepare a pipeline of future Implementation Facilitators?*

- At entry level, a person might first work as part of an implementation facilitation team. On-the-job learning is essential.
 - Entry requirements might include some customer service experience and sufficient IT literacy skills.
 - Project management and support role skills are advantageous, including excellent communication skills and emotional intelligence.
- At an advanced level, IF is a postgraduate level position, which requires a few years of work experience from the sector.
 - Industrial placements as part of postgraduate studies to provide real facilitation experience, and crucially, sector specific experience, will help in the development of implementation facilitation skills.
 - All interviewees reported on-the-job learning being an important part of their professional development.

Degrees or courses that could support the development of implementation facilitation, e.g.:

- Improvement science
- Quality improvement and implementation science
- Evidence-based social intervention and policy evaluation
- Evaluation and research methodologies
- Service design course; user-centred design
- Managing change and innovation
- Facilitation training
- Data science / data skills
- Library or information science

4.4 Knowledge Engineers

4.4.1 Description

Knowledge Engineering (KE) is a domain of artificial intelligence (AI), which constructs rules to apply to data to emulate or imitate the thought processes and behaviours of human experts in a given field. In the health and care context this could for example be in clinical decision making. ^[27-29] The purpose of KE is to create an expert system that assists with “*issues related to their programmed field of knowledge*”, be it financial services, healthcare, medicine, law or customer services ^[27]. Expert systems are computer programmes that use AI to simulate expert knowledge held by a human or an organisation ^[30]. These involve large, expandable knowledge bases combined with rules-engines, which in combination stipulate how information held in the knowledge base is applied to each particular situation ^[27].

Knowledge Engineering seeks to deconstruct a task or a decision process and identify how the human expert reaches a conclusion, and then recreate a system that will arrive at the same result as the expert, without necessarily following the same path. This entails looking at the structure and processes by which a decision is reached in combination with metadata, which is information about a data object that describes characteristics such as content, quality and format [29].

Materials required for mapping the process include libraries of problem-solving methods and a large body of collateral or tacit knowledge about how decisions, which require analogous reasoning and non-linear thinking, are made. The decision process is then translated into algorithms for use by AI to emulate the thinking process of an expert. Ultimately, knowledge engineering aims to help produce an AI specialist, whose abilities match or even exceed those of its human counterpart [27 & 28].

A Knowledge Engineer (KE) is a new and emergent, highly specialised role. The need for these knowledge experts is anticipated to significantly rise in the near future. Technopedia (2019b) defines KE as a professional who *“is engaged in the science of building advanced logic into computer systems in order to try to simulate human decision-making and high-level cognitive tasks”*. In practical terms, a KE provides some or all of the knowledge that is eventually built into the technology and translates that into use by the system [31].

KE tasks may include:

- Creating, capturing, sourcing, evaluating, combining, organising, and enabling discovery and dissemination or transfer of the knowledge to be delivered through technology to meet user needs;
- Building of advanced logic into computer systems to simulate human decision-making and high-level cognitive tasks;
- Managing databases;
- Engaging with customers/future users;
- Working as part of a software development team;
- In the context of health and care, this also requires working with and/or in teams of healthcare professionals.

4.4.2 Findings: Knowledge Engineers

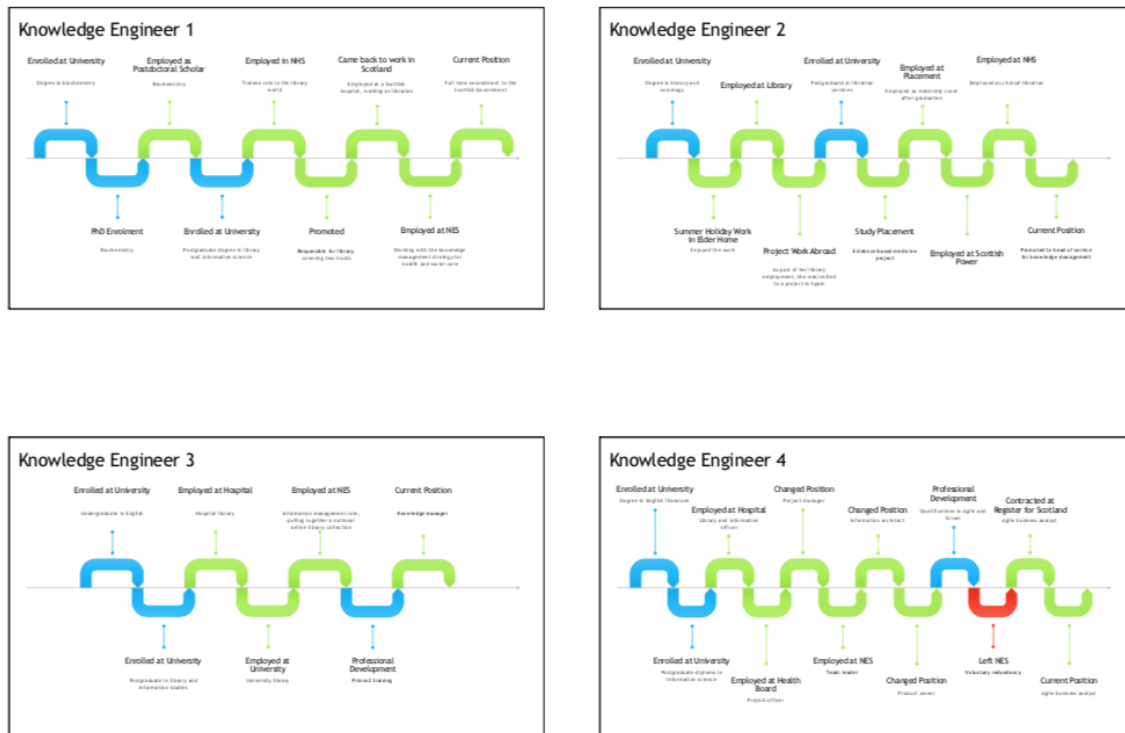


Image 4.4: Knowledge Engineer maps. Full size maps are available in Appendix 2. Blue indicates education/training; green employment; red a turning point or life event.

- All Knowledge Engineers in the cohort had gained academic qualifications.
 - Their undergraduate degrees are from different disciplines (English, history and sociology, biochemistry);
 - All have postgraduate degrees either in information science or librarian studies.
- All representatives have worked as librarians at some point of their career and moved into Knowledge Engineer positions from there.
- Their librarian careers have entailed the digitization of services or working as part of digital library/information services.
- All interviewees occupy senior positions.

4.4.3 How skills are learned

Please, see the full skills and capability table for Knowledge Engineer in Appendix 5d.

- Knowledge Engineer is an emerging role related to the rise of AI.
- There is currently no single qualification that would prepare a candidate for this role.

- Knowledge Engineer is a highly specialist, hybrid role, focussed on translating human behaviour and knowledge into algorithms for use by AI.
 - The role requires postgraduate level education in Informatics or a related field.
 - Substantial work experience in a range of roles from an information, knowledge and data related field is required.
 - High levels of cognitive skill and emotional intelligence are needed.
 - Person suited to this role will enjoy problem-solving, working with data and in an analytical capacity.
- Like Implementation Facilitator, KE requires an exceptional battery of soft skills, such as social skills, emotional intelligence, creativity, the ability to think outside the box in order to develop innovative approaches to tackle problems, ability to drill down the problem and articulate problems. The softer skills can be trained in a software development context.

As the need for these professionals will grow in the Health and Care sector given the rise of AI technology, the question is: *how to begin to prepare a pipeline of future Knowledge Engineers?*

- At an entry level, an undergraduate degree is required to provide basic understanding of research and analytical skills.
- Gaining relevant work experience is a way of accelerating the career development process, e.g.:
 - in a library or digital archive context, or a data analyst;
 - as an assistant to a Knowledge Engineer.
- At a more advanced level, KE is a postgraduate level position that requires a few years of work experience from the sector.
 - Working, for example, as a data scientist, information and data analyst, digital archivist, business analyst etc. will help to hone-in on data and analytical skills, and the ability to deconstruct and reconstruct information to create models and algorithms that will underpin decision support.
 - Learning on the job would be an accelerator to this type of role: industrial or work placements at an AI-company or an AI-development project as part of the postgraduate studies would provide real knowledge engineering and sector experience.
 - Creating opportunities for Modern or Graduate Apprenticeships to work as part of a KE team would be a good way to learn what the role entails and start developing the high-level skills required in the job.
 - Upskilling existing staff.

Useful degrees include:

- Informatics
- Computing science
- Data science
- Information science

- Librarian studies
- Business analysis

4.5 Health Data Analysts

4.5.1 Description

Today, data is one of the main assets owned by any organisations and is vital for driving decision making. Healthcare Data Analysts (HDAs), sometimes referred to as Healthcare Business Analysts or Health Information Management Analysts, oversee data acquisition, management, analytics and interpretation directly to healthcare data. HDAs are quantitative specialists, who understand the business needs of a hospital or other healthcare organisations and are able to translate data into actionable insights for use by clinicians, clinical researchers, decision makers and others. The best Healthcare Data Analysts are diligent problem solvers, who use data in creative ways to support business goals. ^[32-34]

Healthcare Data Analysts work for the NHS, NHS Information Services Division, research institutions, insurance companies, electronic health record companies, the government and much more ^[32-34].

Public Health Data Analysts work for public health and form the force behind medical research. They can be employed by government agencies, private companies, research centres, hospitals, and more. Majority of their time goes into processing raw data to search for trends, patterns and strategies that can improve the public health. Visualising, and communicating their findings, as well as maintaining databases, is an important part of the job ^[35].

HDA duties include:

- Gathering, organising and managing large and varied data sets.
- Responsibility for the analysis of health and care data to help organisations improve their quality of care, introduce savings and service efficiencies to reduce costs, and enhance the overall patient experience.
- Communicating their findings through the use of data visualization and detailed reports to help the executives and heads of operations to understand how to improve their services.
- Developing initiatives to provide more effective healthcare.
- Resolving current service issues through analysis of data.
- Designing new approaches to health and care delivery.
- Managing multiple projects; careful time- and expectations' management.

It is worth highlighting that the role of Health Data Analyst is going through a transformation with the rise of Big Data, automation, cloud-computing and AI as Health and Care organisations are finding ways to benefit from these innovations in the running of their services. This will mean a lot of the tasks related to data gathering, cleaning and organisation will become automated, and the emphasis of the job will be on interpretation of data and on generating intelligence to support better decision making [32-34].

4.5.2 Findings: Health Data Analysts



Image 4.5: Health Data Analyst maps. Full size maps are available in Appendix 2. Blue indicates education/training; green employment; red a turning point or life event.

- Three Health Data Analysts (HDAs) work for health and care, one in academia.
- All Health Data Analysts have academic qualifications, three with postgraduate degrees.
 - The HDAs academic backgrounds range from social policy, international business, medical physics and sports science to public health.
- Three representatives have at some point in their careers been working in research roles within the academia.

- All have pursued other career paths before embarking on one in health data analysis.

4.5.3 How skills are learned

Please, see the full skills and capability table for Health Data Analyst in Appendix 5e.

- Well-established routes into becoming a Data Analyst exist. It is possible to take both undergraduate and postgraduate degrees in, e.g.;
 - Data analytics
 - Data science
 - Health informatics
 - Health information analysis
 - Computing
- A lot of the skills required by Health Data Analysts can also be learned on the job.
- The early career roles often entail data entry and simple analytics.
 - Excellent IT-skills and some knowledge of coding languages, specifically SQL used by most NHS systems, is essential. Can be learned as part of the job as well.
- Data analysts and data scientists are required in every sector, and there is high competition between sectors for qualified Data Analysts. The Health and Care sector is not able to compete in available salaries.
- Suggested solutions include:
 - Raising awareness of career opportunities in data roles within the Health and Care sector should start already at schools.
 - Raising awareness of what a pivotal role HDAs play in decision-making and improvement of services in Health and Care.
 - Paid internships and work placements within the Health and Care sector need to be embedded into the existing courses.
 - Modern and Graduate Apprenticeship places in Health Data Analytics should be made available to get new staff trained for the needs of the healthcare system. (this is a demand led process, more work to be done to make employers in this space aware of opportunities available through MA and GA route)

- Ensuring that accessible provision (local or digital delivery) is available for employers and candidates.

In the future, the Health Data Analyst job becomes more about intelligence extraction and communication, programming and ensuring relevant information is unearthed from the vast amounts of data. Health Data Analysts will play a rapidly increasing role in hospital business management and decision making. The Data Analyst departments may also be merged across health boards, which makes these departments larger, but may also reduce the number of vacancies. This will have implications for the future training and recruitment of Health Data Analysts.

4.6 Cyber Security Specialists

4.6.1 Description

Cyber security (also known as information technology security or electronic information security) is an expansive field, which affects every aspect of digital life. Its importance will only grow as the digital transformation of the society progresses. Its role in the Health and Care sector is critical and will increase with the adoption of AI, machine-learning, cloud services, Internet of Things (IoT), wearable and mobile monitoring technologies and the expansion in patient supplied data. One of the most transformative things for the health and care services will be the amount of data that will be made generated in the sector in the next few years. This will impact every job role in the sector, with specific implications for cyber security.

Cyber security has been defined as the body of technologies, processes, and practices designed to protect networks, devices, programs, and data from attack, damage, or unauthorized access ^[36-38]. Cyber resilience is a recent concept, and slightly broader in meaning than cyber security. Cyber threats have become a regular occurrence, and cyber resilience refers to the organisation's ability to prepare for, respond to and recover from cyber-attacks ^[39]. The hardest challenge to tackle in cyber security is the fast-evolving nature of security risks, which places a lot of pressure on cyber security staff and organisations ^[36].

The NHS and care services, like all other large organisations, collect, process and store huge volumes of data on various types of computers, devices, platforms and data bases. These sets of data are transmitted over digital networks as part of the daily business of the aforementioned organisations. A significant amount of that data is considered sensitive, such as personal information, health related data, financial details or intellectual property ^[36 & 40]. At the same time, according to IT Governance

UK (2019c), it is Health and Social Care industries that are experiencing the highest number of data breaches annually ^[41].

Cyber security issues within health and care do not essentially differ from those in other sectors. The main elements of cyber security include ^[38 & 42]:

- Application security (keeping apps threat free);
- Information security (protecting integrity and privacy of data in storage and in transit);
- Network security (securing information networks from intruders);
- Business continuity planning (cyber resilience planning, plans for recovery from attacks);
- Operational security (protecting data assets: rules about sharing, storing and accessing data);
- End-user education (addresses the weakest link in cyber security: humans); and
- Leadership Commitment (ensuring leadership is behind cyber security plans).

With the majority of services going through digital transformation, it is the responsibility of everyone in the society to be more cyber security-minded. Cyber security issues focus around the three pillars of people, processes and technology^[40 & 42]. IT Governance UK (2019a) defines the three pillars as follows ^[42]:

- 1) *People* - each employee in an organisation needs to be aware of their own role in preventing and reducing cyber security threats; specialist cyber security staff need to keep abreast of latest the skills and qualifications to respond to cyber-attacks and mitigate their impact.
- 2) *Processes* - are crucial in defining how the organisations activities, roles and documentation are used to reduce and mitigate the risks to the organisation's information. These need to be continually reviewed, evaluated and adjusted to respond to the fast-changing nature of cyber threats.
- 3) *Technology* - understanding the types of cyber threats the organisation is facing, it is possible to decide which controls can be put in place to prevent or reduce the impact of cyber risks.

Cyber security is a fairly eclectic, interdisciplinary domain with little standardization on how the cyber security roles are defined. Different Cyber Security roles include:

- Security analyst – analyses the security and vulnerability of the infrastructure;
- Security engineer - looks at monitoring security, do forensic analyses;
- Security architect - designs security of the systems;
- Security programmer – designs security software; integrates security into the software during design process;
- Security administrator - installs and manages the organisation security;
- Security software developer - designs secure systems;

- Everyone in the Cyber Security cohort has a technology-related first degree.
- Qualification levels between the interviewees varied from Higher National Diploma to PhD.
- All have progressed their careers in IT-related jobs in other sectors before moving into Health and Care.
- All interviewees have moved into Cyber Security roles through postgraduate, additional or work-based learning. This reflects the emergence of Cyber Security roles as part of the IT-infrastructure over time.
- All representatives have continued their professional development at work, whether it is through PhD enrolment, certifications, CPD courses or other.
- The younger colleagues have had the opportunity to study cyber security, ethical hacking and penetration testing on dedicated courses. This reflects how the importance of this occupational category has been increasing over time.

4.6.3 How skills are learned

Please, see the full skills and capability table for Health Data Analyst in Appendix 5e.

- There are different entry points into a career in cyber security in Health and Care. These career opportunities are on the increase.
- Today there is a range of undergraduate and postgraduate degrees available e.g. in Cyber Security, Secure Programming and Ethical Hacking in Higher and further education.
- Working in CS requires the ability to continually develop your skills and knowledge, and to keep abreast with the fast pace of technology development.

As with Software Developers, the main question for Cyber Security Specialists is how to attract more people into the sector. Suggested means include:

- Raising awareness of Cyber Security as a sector and of the career options within it. The process needs to start already at schools and continue at all levels of education, as well as among health and care staff, and IT-specialists.
- Upskilling/reskilling of existing health and care, or IT-staff in cyber security roles.
- Promoting non-technical cyber security roles, such as the Cyber Security Consultant.
- Developing suitable CPD training courses for upskilling/reskilling staff for cyber security roles.

- Improving take up of Modern Apprenticeship (MA) and Graduate Apprenticeship (GA) schemes across the whole spectrum of the digital health and care roles.
 - Setting up the schemes will require having relevant education providers in the area of the health boards or local authorities.
 - Planning and creating these schemes in collaboration with local education providers would not only help raise awareness of the sector, streamline the process of recruitment and availability of apprenticeship opportunities at the NHS and the Care sector, but also ensure the education and training requirements set for the MA's and GA's will be met.

4.7 Three proposed roles for cyber security in the health and care context

The three proposed Cyber Security Specialist roles in the health and care context align with the three pillars of cyber security discussed in Chapter 4.6.1. These suggestions do not exclude other cyber security roles in health and care. We have treated these proposed categories like the other five and examined the required skills and capabilities for them. In addition to the skills listed below, all roles include soft skills such as problem-solving, critical thinking, communication, active learning strategies etc.

4.7.1 “Cyber Security Consultant”

Description

Cyber security is a concern for everyone in the workforce. The Cyber Security Consultant is the go-to person in cyber security matters within their professional group, be it surgeons, nurses, allied health professionals or admins, catering staff or porters, etc.

The role entails cyber security peer support and training on cyber security matters, on online safety and in good practice in engaging with digital as part of day-to-day work. This would include the use of various digital devices as well as the internet and the intranet and of how to recognise cyber security threats and how to deal with these.

Cyber Security Consultant has to keep up to date in the latest cyber security developments and communicate closely with Cyber Security Administrators and other cyber security professionals in their organisation, conveying any urgent cyber security updates or threats to their colleagues.

As the NHS and the Care sector are such multifarious environments with varying work environments and practices, it will be easier to upskill/retrain a health and care practitioner in cyber security matters, than a Cyber Security Specialist in every aspect of the NHS or the care system. Depending on the size of the organisation,

each professional category could have their own Cyber Security Consultant. In smaller organisations, such as a GP's practice, one person could oversee this role (perhaps in conjunction with other cyber security responsibilities). The role would be suitable for a career changer or as a part-time role in combination with the person's day-to-day work.

How skills are learned

Please, see the full skills and capability table for Cyber Security Consultant in Appendix 5f.

- This role requires an in-depth understanding of the specialist domain the CS Consultant will work in, such as nursing.
- It is easier to upskill a clinician or a nurse in cyber security matters than train a Cyber Security Specialist in all the intricacies of the health and care system.
- It is envisaged that this role would require additional Continuing Professional Development and the ability to keep up-to-date with latest developments in technology and in cyber security in relation to the person's main occupation.
- Doing an MSc in Cyber Security would be useful but learning the role would not necessarily require doing a full degree.

4.7.2 "Cyber Security Administrator"

Description

Cyber Security Administrator is a systems-oriented professional, who oversees the security of the digital infrastructure and all connected devices. The role is characterised as "the first line of defence for threats".

In-depth knowledge of health and care is not required, but the Cyber Security Administrator has to have a full understanding of all the elements of the infrastructure, including all the apps and devices connected to the system, and how and why these are used.

The role entails scanning the system for threats and dealing with them in an efficient and prompt matter; alerting the rest of the users to the existing threats; communicating closely with Cyber Security Consultants and other relevant professionals.

How skills are learned

Please, see the full skills and capability table for Cyber Security Admin in Appendix 5g.

- A degree in computer science and/or background in cyber security required.
- Ability to continuously learn and update your skills as part of the job is required.
- Modern or Graduate Apprenticeship could a useful route into this type of role in health and care.

4.7.3 “Cyber Security Architect”

Description

Cyber security is a feature that each app, digital device and digital network ought to have included in its design from the beginning at all levels. It is the job of the Cyber Security Architect is to ensure that this is the case. Until recently, cyber security considerations were not taught as a standard at many software engineering and software design courses, even if individual modules might have been on offer.

Cyber Security Architect works as part of a software design team, often leading a team of their own. Their task is to ensure that security considerations are taken into account and designed into all levels of the system from the beginning. Overall, critical infrastructure systems in different sectors are fairly similar: these include confidential data that requires protection; rules and regulations relating to data and information governance, etc. Hence, as with Cyber Security Administrator, in-depth knowledge of health and care is not required, but the Cyber Security Architect has to have a full understanding of all the elements required in the infrastructure, including all the apps and devices that need to connect to the system. They will need an understanding of device compatibility and standards, and what the devices do and are used for and who by.

How skills are learned

Please, see the full skills and capability table for Cyber Security Architect in Appendix 5h.

- A degree in computer science, software development or secure programming required.
- Ability to continuously learn and update your skills as part of the job is required.

5 Addressing future workforce development issues in the Digital Health and Care

5.1 Raising awareness of career opportunities in Digital Health and Care

At the beginning of this study, our aim was to identify and sketch out educational and career pathways for the six occupational categories investigated in this study through interviewing people working within them. Instead, we discovered a more profound concern affecting the job market: *that there is a general lack of awareness of the diverse career opportunities in the Digital Health and Care sector*. This concern was raised by most research participants and is the primary issue to address to help develop the future workforce in Digital Health and Care.

Career options within Health and Care are becoming more diverse with digitisation, AI, machine-learning, Big Data, cloud-computing, automation, etc. These innovations will expand the range and number of non-medical professionals working within health and care, widening the possibilities to make a difference to people's lives beyond clinical and care roles. While school leavers may be aware of existing educational opportunities e.g. in software development, data analysis and cyber security, they are not fully, and in some cases at all, aware of the career opportunities for these professions within the Health and Care sector. Furthermore, certain occupational categories, such as Knowledge Engineers and Implementation Facilitators, are almost entirely unknown to those outside of the sector. However, as the use of digital continues to grow in the delivery of health and social care, these roles will gain more prominence.

The research participants suggested starting awareness raising campaigns in the early stages of children's development, beginning with introducing nursery, primary and secondary school pupils, their parents and teachers to the range of alternative career options within health and care. This requires a better definition of career options and pathways, definitively naming certain job roles, and the creation of materials to support the previously mentioned campaigns. The lack of awareness of existing job opportunities and the lack of job role definitions within most of the categories was identified as a major problem. For example, Knowledge Engineering and Implementation Facilitator roles raised a lot of discussion among the development workshop participants. This includes issues such as what these roles entail in practice, and whether or not the names used should change in future. For cyber security, the recruitment issue was not specific to Health and Care sector but focussed on the general lack of awareness of cyber security itself as a career option and what the day-to-day work entails. Addressing that was seen as the primary concern for staffing in Digital Health and Care roles.

5.2 Recognising and defining the translational jobs category

Our study identified a new digital role (cf. TechCity 2016), which focusses on the boundary between humans and technologies: translators. These professionals work at the interface of humans and technology, *translating* data, information, intelligence and knowledge for use between humans and computers. In this study, these roles include Knowledge Engineers, Implementation Facilitators, Product Owners and Health Data Analysts.

Based on the WEF (2018) Future of Jobs survey, the demand for roles that are significantly based on and enhanced by the use of technology, based on distinctly human skills, and that relate to understanding and leveraging the latest emerging technologies will accelerate significantly in the near future ^[4]. This is a perfect alignment for translational jobs.

As our skills analysis shows, the translational roles require a very similar set of basic skills and knowledge, albeit the nature of the occupations, and the emphasis of the required skills will vary between roles. However, recognising and defining “Translators” as an important overarching category could help facilitate collaboration, skills transfer, and the development of career pathways based on shared capabilities.

5.3 Taking advantage of the shared skills basis across categories

The study found that although the six (eight⁷) occupational categories examined are distinct groupings, there is a significant overlap between the skills, capabilities and knowledge required to perform them. Many of the skills and capabilities pertain to the so called “soft skills” or “21st century skills”, which employers find increasingly important for staff to have to help cope with the fast-changing world of work.

The shared skills and capabilities -basis opens up an interesting opportunity for education providers and employers alike *to consider organising shared core training for future professionals in these categories*, with the prospect of branching out to the different specialisms through work and further study. This could also have a positive impact in terms of increased flexibility for staff to be able to move between jobs and for the sector to address future workforce issues with lighter additional training. The opportunities for arranging joint training across occupational categories was also identified by DHI (2019) “Our time to Shine” -study ^[3].

⁷ Taking into account the specialist cyber security roles.

5.4 Making the sector more attractive

One well-known recruitment issue in the (Digital) Health and Care sector is its inability to compete with many other sectors in pay. The research participants highlighted the need for the Health and Care sector to rely on other means to make itself more attractive to ICT and cyber security graduates and professionals. Several research participants explained that they had chosen to work in digital health and care because they felt they were genuinely making a difference to people's lives through their work. For example, in developing digital health and care devices or services, or in providing intelligence for use by the NHS to improve the care they offer.

A cyber security expert suggested that professionals in their sector thrive on challenges – the more complicated the problem, the more engaging it is. With this in mind, the NHS, care organisations and digital health businesses should emphasize the intellectual challenge offered by the work. Engaging in value-based recruitment tactics to tap into people's altruistic tendencies and in their disciplinary interests and ambitions over massive pay packages. For example, it was suggested that the NHS should reach out to cyber security, data analyst and software programming students by opening up their (anonymised) data sets for use at hackathons, Game Jams and other events attended by students and IT enthusiasts, and by making their “wicked problems” known to the public.

It was also suggested that the NHS should construct career progression pathways that include salary increases for digital health recruits into the sector.

A strength that the NHS should highlight are the benefits they offer e.g. for working families, including job security, standardised working week, decent holiday entitlement and opportunities to continually develop in your career. This could be a means of attracting more women into the Digital Health and Care sector through upskilling or reskilling to switch careers, e.g. upon return to work after maternity leave.

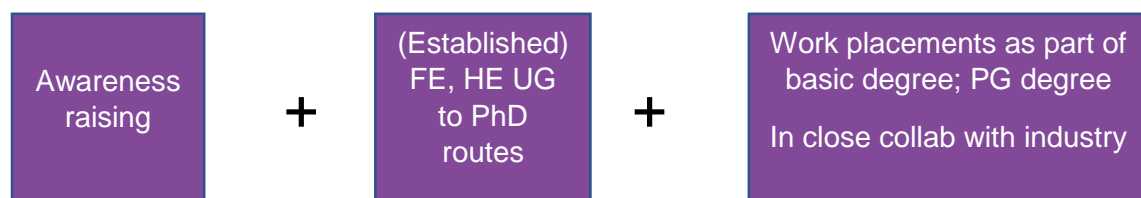
An example of a more creative recruitment campaign to draw people into cyber security comes from Denmark. The Danish Defence Intelligence Service have an annual competition seeking participants for their “Cyber Landsholdet”, a national team of 10 young IT talents aged between 15-25. The competition is a way to recruit young gifted candidates for the Danish Defence Intelligence Service and to increase general awareness of and interest in cyber security. The potential candidates have to complete a “Cyberhunt” - a digital and physical treasure hunt where the participants have to find and solve several challenges to proceed in the selection. The candidates who solve the challenges most successfully and creatively will be invited to a bootcamp to develop their IT knowledge and collaboration skills further before the final 10 candidates are selected. The “Cyberhunt” is advertised on national newspapers and other media, and it has attracted a lot of attention, and participation, from the Danish youth.^[63]

5.5 Signposting graduates into careers in digital health and care

Software Developers and Cyber Security Administrators and Architects have well sign-posted and established educational pathways, which include opportunities for study both at the further and higher education level. The main question for the established occupational categories was how to signpost graduates into the digital roles within the Health and Care sector?

To raise awareness of the sector and to promote careers in (digital) Health and Care as a legitimate and an attractive choice, health and care employers and the Education sector need to engage in strategic collaboration. Firstly, the digital health, and health and care *employers should reach out to education providers to promote the digital employment opportunities* they offer and to increase the visibility of the sector among graduates.

Secondly, the education providers (here: ICT, computing, cyber security, information science and other relevant subjects) should *incorporate work placements into their degree structure to enable students to seek work experience within the Digital Health and Care sector*, and to develop the much-needed soft skills for working life. The research participants pointed out that early engagement of graduates in the sector increases the chances that they might choose to stay as the workplace and context become familiar during their placement. *The Health and Care sector could also create opportunities for paid internships or summer work placements in Digital Health and Care roles* for students from selected sectors.



Another way to promote the Health and Care sector as an employer and expose its digital career opportunities to graduates is to *make interesting final year project topics available to students*. These could be tailored to meet the needs of both the student cohort and the sector, requiring students to engage with the sector in detail in order for them to get to better understand the domain.

Making these opportunities available will require administrative changes both in the Health and Care and the Education sector, which is why careful long-term planning and collaboration between the sectors is essential. A good way to proceed would be to start with the well-established job categories, such as the Cyber Security specialists, Software Developers, Data Analysts/Scientists etc., and expand the reach as clearer education pathways become available for other categories.

5.6 Creating early career pathways for highly specialised jobs

Knowledge Engineer and Implementation Facilitator categories require highly specialised and advanced knowledge and skills, which are often amassed through relevant work experience. These roles are also relatively unfamiliar to many, the Knowledge Engineer category is only beginning to emerge as a recognised job role in the advent of AI and decision support technologies.

All the Knowledge Engineers interviewed had worked as librarians at some point in their careers and studied either library or information sciences at postgraduate level. To work as a Knowledge Engineer requires a degree level, ideally postgraduate level, qualification and relevant work experience, e.g. as a data scientist, information and data analyst, digital archivist, business analyst etc. to hone-in on analytical skills.

In terms of creating early career pathways for Knowledge Engineering, one might study, for example, data science, computing or information sciences at undergraduate level. This could be followed up with undergoing work experience e.g. as a research assistant in information sciences or health data analysis, or a similar research related field, ideally in health and care. Relevant work experience could also be gained from a digital library or a digital archive.

Completing postgraduate qualifications in e.g. information or library science or computing and finding a relevant dissertation topic would be a helpful next step. The topic could for example focus on AI relating to health and care, or on clinical decision support. Also, Graduate Apprenticeship arrangement with a Knowledge Engineer would help build up relevant work experience of knowledge engineering as a job.

Implementation Facilitator's job is very context dependent, and the cohort we interviewed did not share an educational background. It was suggested there was no single qualification that would prepare a person for this role, but a successful IF will require experience from a range of fields and an exceptional battery of soft skills.

A person wishing to become an Implementation Facilitator could start without academic qualifications and work their way up as part of an implementation facilitation team. This would allow the person to gain the necessary practical and soft skills required to carrying out the role. However, to work in this type of a role at an advanced level, postgraduate level qualifications are required, including a few years of relevant work experience.

On-the-job learning is crucial both for Knowledge Engineers and Implementation Facilitators. Industrial placements as part of postgraduate studies for both categories would provide relevant work experience that helps hone-in the development of the required skills set.

5.7 More opportunities for upskilling/reskilling to enhance careers

Product Owner and the envisaged category, Cyber Security Consultant, are roles that a healthcare professional could adopt as part of their day-to-day work, or move into during their career. Usually, a software development project is a time-limited endeavour, which means that a Product Owner role would be temporary. If the Product Owner is a permanent role, this will be external to the health and care context, and this person will work in close collaboration with a health and care professional.

The health and care organisations should firstly recognise these job roles as existing categories, and then make CPD level training available for people interested in enhancing or changing their careers. Some workplace training/job shadowing could also work well with training future POs and CS consultants.

5.8 Renewing Health Data Analyst education

While the Health Data Analyst category shares a lot of the skills requirements with Cyber Security Administrators, Knowledge Engineers and Implementation Facilitators, it is a category that will face the biggest transformation in the next few years. Currently the job entails gathering, organising, cleaning up and storing of numerical data, analysing it and visualising and presenting the findings.

This has entailed a lot of “manual labour” in cleaning up and transferring the data from paper and other sources, and entering it into digital formats and into databases etc. These tasks can also be learned on the job. The analysis of cleaned and processed data requires more advanced skills. With digitisation of Health and Care information systems, automation, AI etc., a lot of the work tasks traditionally carried out by Health Data Analyst teams will become automated: data will flow into the databases as it is automatically gathered by the system, and it can be set to feed in particular formats at particular intervals. The Health Data Analysts’ job will begin to focus more on analysing data, gleaming intelligence and creating future projections to support better decision making in the hospitals and health boards. This means Health Data Analyst training will need to meet the future requirements.

6 Recommendations

The report makes the following recommendations:

- 1 **Raise awareness of career opportunities in Digital Health and Care** among career advisers, parents, school staff, students, education providers, perhaps via a strategic information campaign.

- 2 **Strategic collaboration between the industry/employers and the education and skills system** – to influence core curriculum, create education and career pathways, and embed placements and internships as part of degrees.

- 3 **Improve the attractiveness of the Digital Health and Care sector** by focusing on unique selling points (genuine challenge, values).

- 4 **Raise awareness of the core skills and capabilities** required in the sector, including soft skills, among education and training providers, employers, students etc.

- 5 **Create a core education/training provision** for the six categories, allowing for opportunities for specialisation later on in the degree, and for a more flexible movement between job categories.

- 6 **Create early career opportunities for translational job categories.**

- 7 **Create CPD opportunities to upskill/reskill existing staff and attract new talent to the sector** – young people as well as experienced staff (incl career changers) from other parts of the economy.

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Appendixes

Appendix 1a: Interview schedule

Career pathways in Digital Health and Care - Interview schedule

Dear Participant,

Thank you for taking the time to be a part of our study that explores emerging career pathways in the Digital Health and Care sector.

We have asked you to take part in a short interview in your capacity as a professional working in Digital Health, with a view of mapping out your career to date.

During this interview we will be asking you questions about your career, your current job, and your educational background in order to 'map' the path of your career to be able to visualise how you have reached this point in your career. We will compare the paths taken by you and people working in similar roles to yours to see if there are any similarities in these. The findings from this research will form a basis for a design/development workshop with education providers, employers and employees in these fields to construct routes that future professionals might be able to take to work in similar roles.

The interview will be free form, and while we talk, I will be sketching a map of the career steps you have taken to date.

First of all, please tell us a bit about your current role and we will work back from there.

1. Overview of the current role

- a. Can you give us an introduction to where it is that you work and the purpose of your company/organisation?
- b. Could you please tell us about your current role? What do you do?
- c. What do you think are the top skills required in your role?
- d. Did you learn these skills 'on the job' or did you learn these during education?

2. Retrospective mapping of the career pathway and influencing factors

- a. Following the overview of the current role, the interview will progress retrospectively step by step. We will ask you to describe your previous job roles, the required skills, how and why you acquired the role in question, what influenced their decision to change jobs, what helped you to get the job, etc. The questions include information on any education, training or other significant contributing factors to progression your job.

3. Barriers and enablers in your chosen career

- a. As your map is ready, we will discuss the map with you to check our mutual understanding of how the career has progressed. We will also ask you about any barriers and enablers that have had an impact on your career progression.

4. Finally - any advice?

Can you part some wisdom for the people who are just starting their journey?

- a) What do you think (if anything) you would have done differently along the course of your career, looking back in hindsight?
- b) What do you see as being the current or most emergent skills gaps in your organisation or team?
- c) Do you think there are certain career pathways that need to be promoted within the Health and Care sector?

5. Any other comments you'd like to add?

8 Thank you | End of interview

Appendix 1b: Project Information Sheet and Consent Form

Participant Information Sheet for employees in the Digital Health and Care sector in Scotland

Name of department: Digital Health and Care Institute

Title of the study: Career pathways in the Digital Health and Care sector

Introduction

Digital Health and Care Institute (“DHI”), established in 2013, is one of eight Scottish Innovation Centres supported by the Scottish Government. DHI is currently hosted by, and forms part of, the University of Strathclyde.

The objective of the DHI is to co-produce innovative and integrated, digitally enabled and scalable solutions benefiting the health, economic and educational wellbeing of the people of Scotland. DHI brings together industry, academic and civic partners to respond to demand led challenges.

The Research and Knowledge Management (“RKM”) team provide an in-house research service for DHI staff and key partners in support of fulfilling the DHI objectives. The researchers involved in this particular study are:

- Dr Sanna Rimpiläinen, Research and Skills Manager
- Mr Ciaran Morrison, Research and Knowledge Management Officer
- Ms Laura Rooney, Research and Knowledge Management Officer
- Mr Soren Lange Nielsen, Marketing and Comms Officer

This study has been granted ethical approval by the DHI Departmental Ethics Committee, which consists of Prof George Crooks, CEO; Dr Marilyn Lennon and Dr Liane Lewis, CIS, University of Strathclyde.

You can contact the team at research@dhi-scotland.com for any queries.

What is the purpose of this research?

This study investigates the career pathways of people employed in six of the most urgently required occupational categories in Digital Health and Care sector in order to develop better defined career pathways for people wishing to follow a Digital Health and Care career. The occupational groups included in this study are: Software engineer/developer; Product owner; Software implementation facilitator; Cyber security specialist; Knowledge engineer; and Health data analyst.

The DHI has been commissioned by Skills Development Scotland (“SDS”) to undertake this study and provide them with a report of the findings.

Do you have to take part?

Your participation in this study is entirely voluntary. You have the right to withdraw from an interview at any point without any detriment to you or your organisation. You also have the right to request that any data or information that you have provided be destroyed.

We will be interviewing you as an individual, not as a representative of your organisation, regarding your current job role, the required skills for that role, your personal career history and your educational background.

What will you do in the project?

- A DHI researcher from the RKM team will arrange a face-to-face meeting with you at the DHI premises, or another mutually suitable, public location. In exceptional circumstances we may carry out the interview via video-link.

- The interview will be semi-structured, and last for about an hour. The interviews will be audio recorded. During the interview the researcher will, in collaboration with you, the interviewee, also sketch a visual representation or a “map” of your career to date.
- The interviews will be carried out by the end December 2018. A development workshop will be arranged in January/February 2019. The study will be completed in March 2019.
- The interview will explore your current role, the requisite skills and the route you have taken to your current job, including any education or training you have undertaken, or any other contributing factors along the way. We will also explore barriers and enablers in your career pathway and ask for any advice or recommendations you could offer for others wishing to work in your line of employment.
- There will be no payment or re-imbursement for your participation. The DHI may cover moderate travel expenses, if the interview is carried out at DHI premises, and if agreed in advance.

Why have you been invited to take part?

You have been approached to take part in the study as a person working in one of the aforementioned six occupational categories within the Digital Health and Care sector either in the public or the private sector.

What information is being collected in the project?

During the interview we will collect information about your current job role, the required skills, your personal career history and your educational background, as well as your personal opinions on what barriers or enablers you have had in your career, for the purposes of developing a visual mapping of your career path to date in order to form an understanding of how you arrived in your current role. During the interview, we will draw up a visual mapping of the career route you took and discuss this with you to ensure we have a shared understanding of that. The interviews will be audio recorded using the encrypted audio recorders; the maps are drawn by hand.

We will not take photographs of your person, nor do video recordings. We may ask for an oral permission to photograph your work environment using work mobile phone cameras. The photos *may be* used for illustration purposes in the final report and other forms of dissemination (e.g. presentations, fact-sheets).

Who will have access to the information?

- All data will be treated confidentially and in accordance with existing data protection legislation (Data Protection Act 2018 and the General Data Protection Regulation (**GDPR**)) as adopted by the University of Strathclyde.
- All data collected during the project will be pseudo-anonymised (i.e. individual participants will not be named); the participants’ job roles will be referred to by the generic occupational categories used in this study; their educational background will be referred to by the level of education rather than by institution.
- Your employer may be identified (such as “NHS” or “Orion Health” - the name of the company) in the ensuing dissemination of findings. *Because of this, we cannot guarantee full anonymity for some participants.*
- The data and information generated through this study will be accessible by the RKM team members as well as the super-administrators of the data repository Strathcloud, who look after the repository, and who are bound with confidentiality rules.
- The raw data will not be shared with any other members of the DHI team or the public.
- We will share pseudo-anonymised data only with our partner and funder of this study, Skills Development Scotland, for the purposes of analysis of that data.
- We will share analysed, pseudo-anonymised data and visual mappings of your career pathway at a development workshop with partners from various public education and training providers, employers and selected study participants, who have provided us with their email in the consent form in order to be contacted by us following the interview. At this stage of the project we are unable to name these stakeholders in more detail.
- Following the completion of the study and publication of the findings, *fully anonymised career pathway mappings* will be deposited at the University of Strathclyde PURE – University of Strathclyde data repository - where it will undergo curation and preservation. These data will be anonymised, and licensed under the Creative Commons license CCBY, which enables the research to be distributed,

remixed, tuned, and built upon, even commercially, provided the original creators are given credit for creation of the original data.

- Findings from this study will be published and stored at the Strathprints open access repository at the University of Strathclyde, the DHI and SDS websites, as well as disseminated at various public events.

Where will the information be stored and how long will it be kept for?

- Data and information generated through the study (interviews, transcripts, sketches, photos, and analyses) will be stored on password protected, encrypted personal laptops, and deposited in Strathcloud at the University of Strathclyde, where it will be stored within folders made only visible to and accessible by RKM team members.
- Upon completion of the study, anonymised research data will be deposited in PURE – University of Strathclyde data repository - where it will undergo preservation and curation.
 - As this data consists of *personal information*, including details of your career and educational history, background etc., we will deposit *only fully anonymised career pathway mappings* (including removing the name of the company/organisation) in PURE for five years from the generation of data by the researchers. All data will be destroyed after five years.
 - We will keep your name, and if you have provided us with this, your email address, in a separate file to your data for a duration of five years, upon which these data will be destroyed from the university's files.

Thank you for reading this information – please ask any questions if you are unsure about what is written here.

Please also read our Privacy Notice for Research Participants.

What happens next?

- If you are happy to be involved in our study, we will ask you to sign a consent form to confirm this.
- If you choose not to take part, we thank you for your attention.
- The participants who have provided us with their email address, and whose data is selected to be used as part of a case-study, will be given a time-limited opportunity to review the case study prior to publication.
- The participants who have provided us with their email address *may be* invited to participate in the development workshop for these career pathways.
- We will make the final report available to the all participants in the study on the DHI web-site.

Researcher contact details:

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This research was granted ethical approval by the DHI Departmental Ethics Committee.

If you have any questions/concerns, during or after the research, or wish to contact an independent person to whom any questions may be directed at, or further information may be sought from, please contact:

Secretary to the University Ethics Committee
Research & Knowledge Exchange Services
University of Strathclyde
Graham Hills Building
50 George Street
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G1 1QE

Telephone: 0141 548 3707

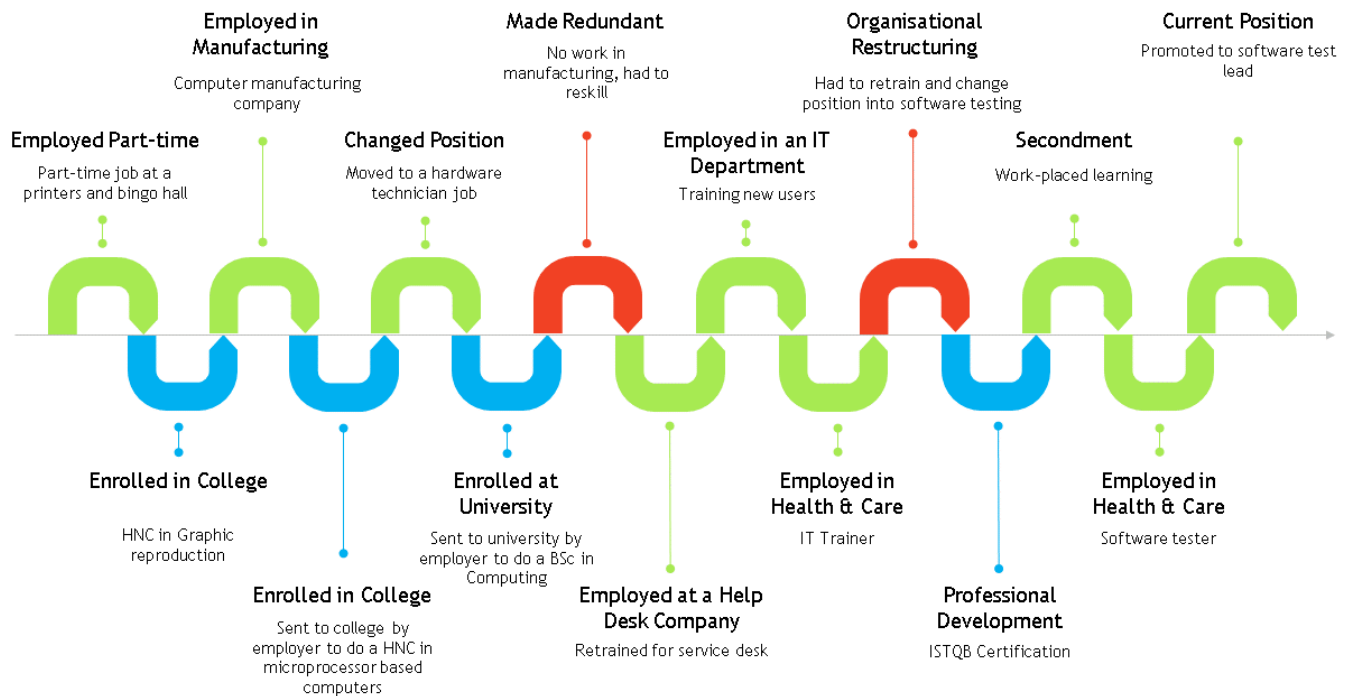
Email: ethics@strath.ac.uk

Consent Form for employees in the Digital Health and Care sector in Scotland

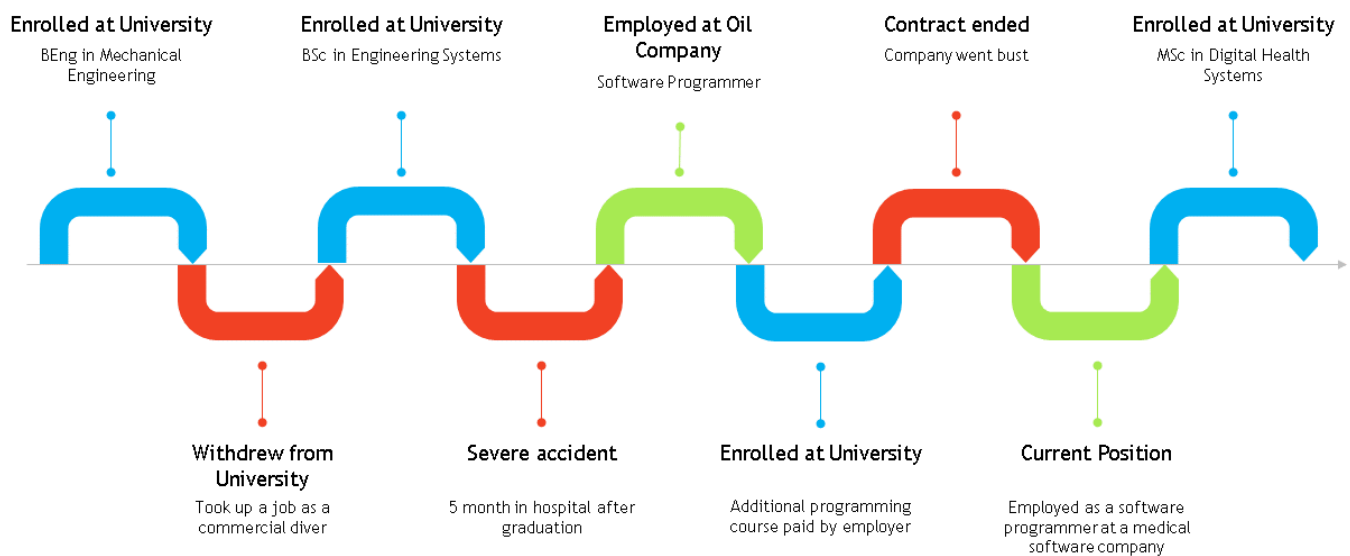
Name of department: Digital Health and Care Institute	Y	N
Title of the study: Career pathways in the Digital Health and Care sector		
• I confirm that I have read and understood the Participant Information Sheet for the above project and the researcher has answered any queries to my satisfaction.	<input type="checkbox"/>	<input type="checkbox"/>
• I confirm that I have read and understood the Privacy Notice for Participants in Research Projects and understand how my personal information will be used and what will happen to it (i.e. how it will be stored and for how long).	<input type="checkbox"/>	<input type="checkbox"/>
• I understand that <i>my participation is voluntary</i> and that I am free to withdraw from the interview at any time, up to the point of completion, without having to give a reason and without any consequences.	<input type="checkbox"/>	<input type="checkbox"/>
• I am aware I shall be asked to answer questions regarding my current employment, my personal career history, and my educational background, as well as my personal opinions about what is useful for progressing a career in the digital Health and Care sector. I understand that I answer these questions as an individual.	<input type="checkbox"/>	<input type="checkbox"/>
• I understand that any information recorded in the research will remain confidential and no personal information that directly identifies me will be made publicly available.	<input type="checkbox"/>	<input type="checkbox"/>
• I understand that while my personal details (name, date of birth, address, etc.) will not be revealed, my occupational category and the category of my qualifications will be named, and my employer <i>may</i> be named. Therefore, <i>I am aware that due to my job role in a public organisation the researchers cannot always fully guarantee my anonymity as an employee of such an organisation.</i>	<input type="checkbox"/>	<input type="checkbox"/>
• I understand that I can request the withdrawal from the study of some personal information and that whenever possible, researchers will comply with my request. This includes the following personal data: <ul style="list-style-type: none"> ○ audio recordings of interviews that identify me; ○ my personal information from transcripts. 	<input type="checkbox"/>	<input type="checkbox"/>
• I understand that anonymised or pseudo-anonymised data (i.e. data that do not identify me personally) cannot be withdrawn once they have been included in the study.	<input type="checkbox"/>	<input type="checkbox"/>
• I consent to being contacted by the research team following the interview, a) in the event that I may be invited to participate in a focus group/development workshop for constructing career pathways for digital health, or b) in case my data is used in a case study, for the research team to make the draft case-study available to me for a time-limited period for review prior to publication. Please, tick box if you agree to this: <input type="checkbox"/>		
email address: _____		
• I consent to being audio recorded as part of the project.	<input type="checkbox"/>	<input type="checkbox"/>
• I consent to being a participant in the project.	<input type="checkbox"/>	<input type="checkbox"/>
(PRINT NAME)		
Signature of Participant:		Date:

Appendix 2a: Career maps – Software Developers

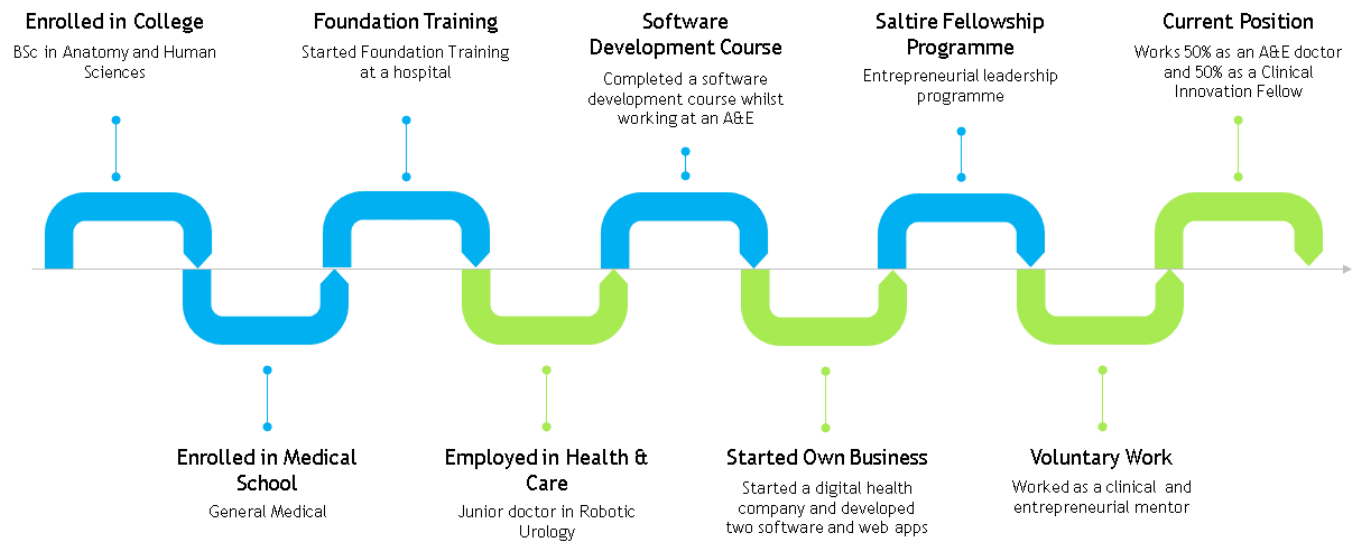
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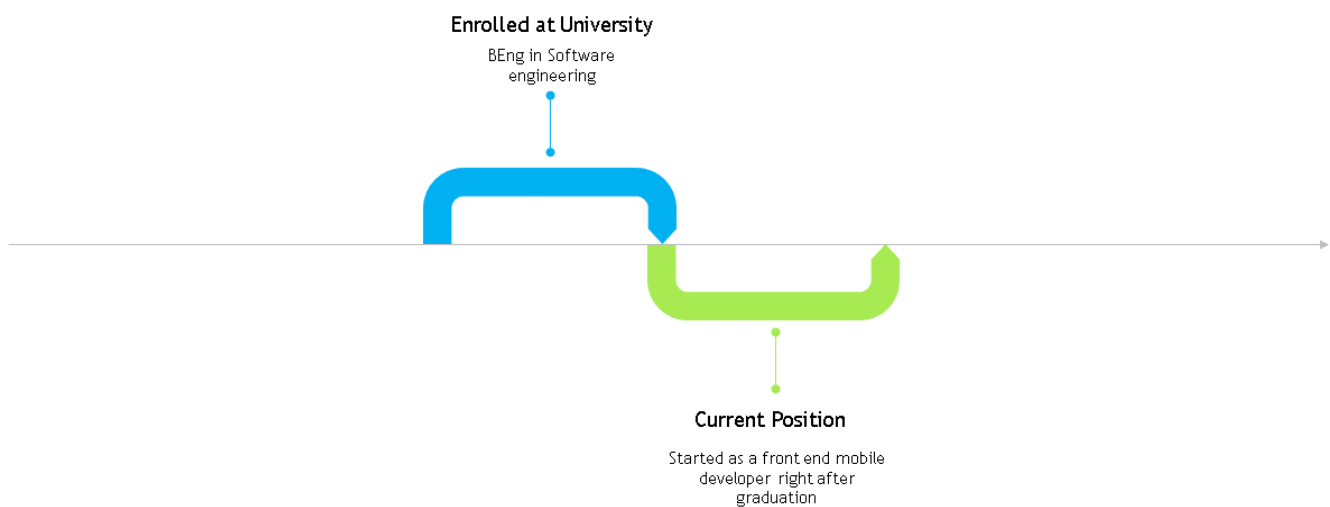
Software Developer 2



Software Developer 3

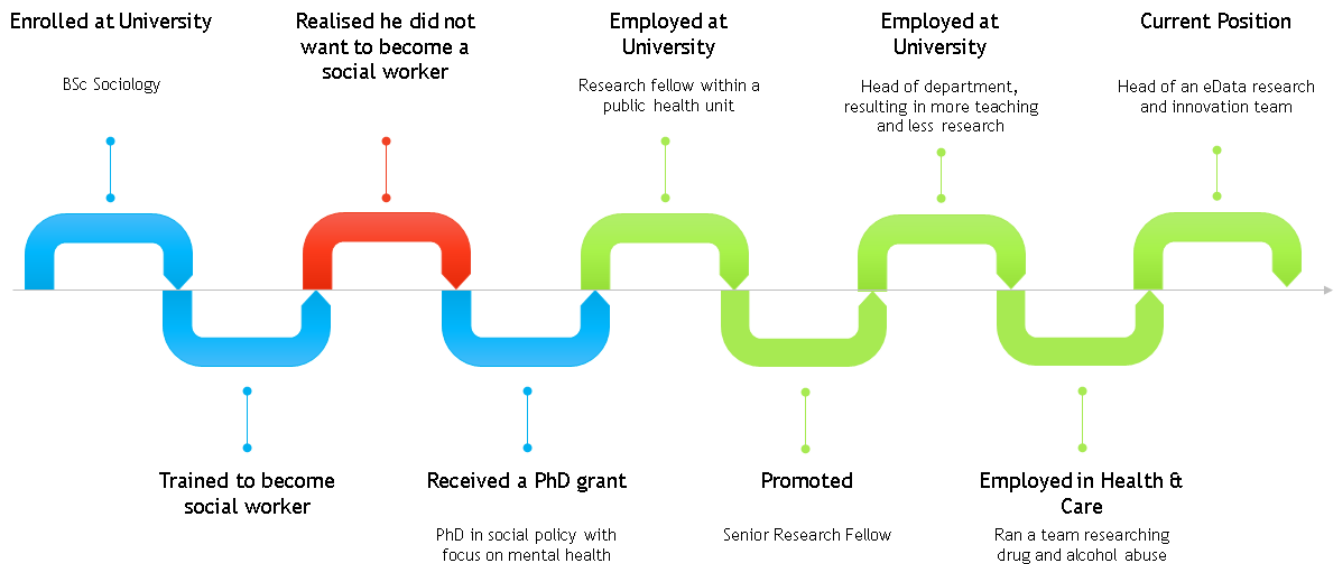


Software Developer 4

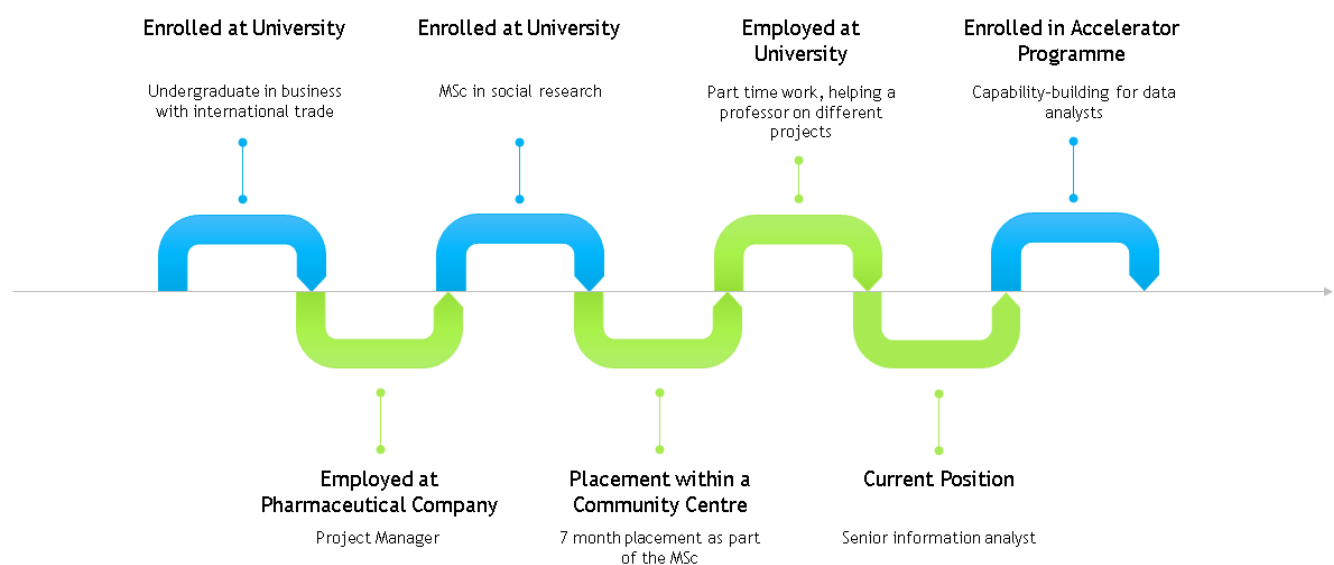


Appendix 2b: Career maps – Health Data Analysts

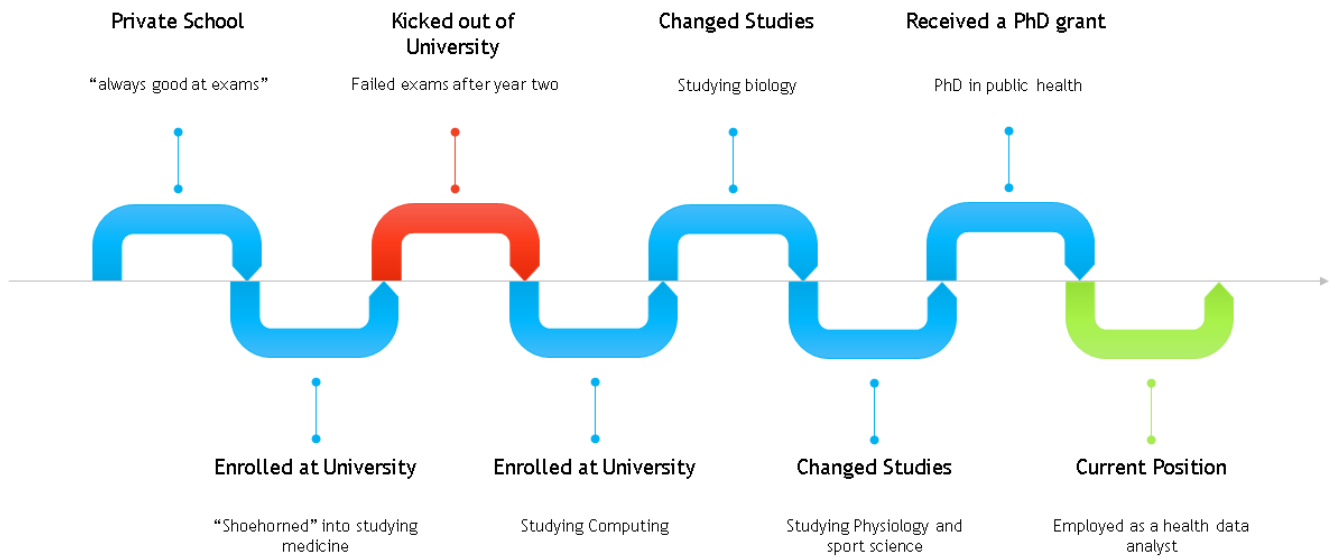
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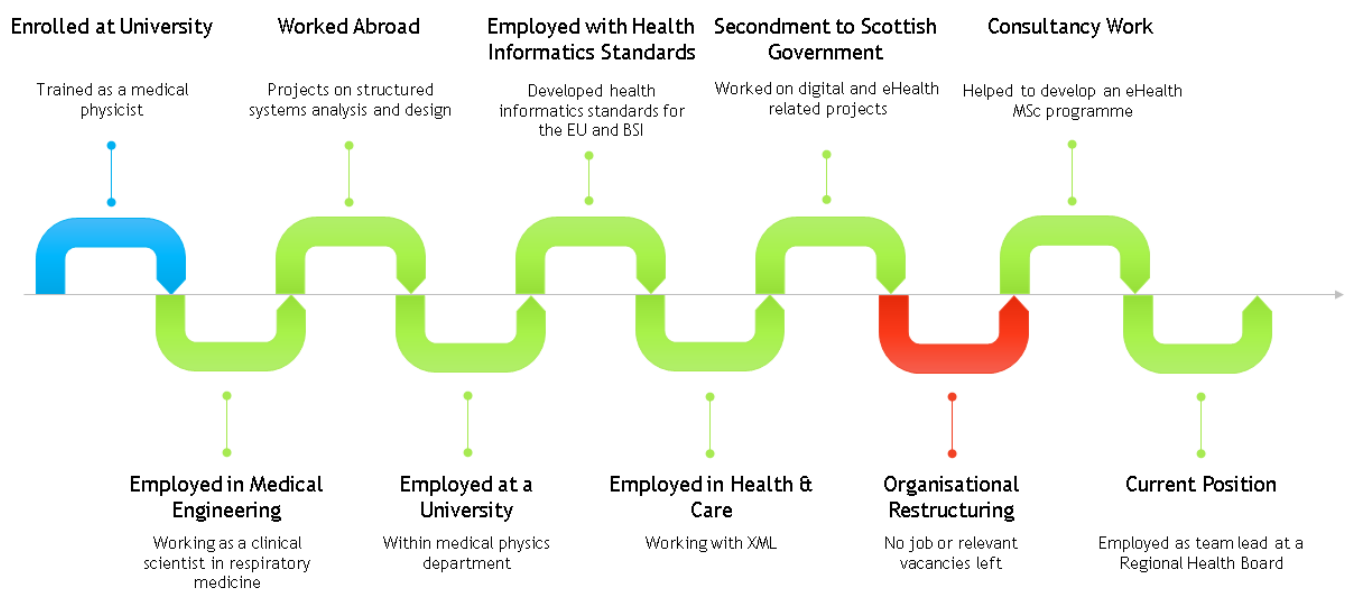
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Health Data Analyst 3

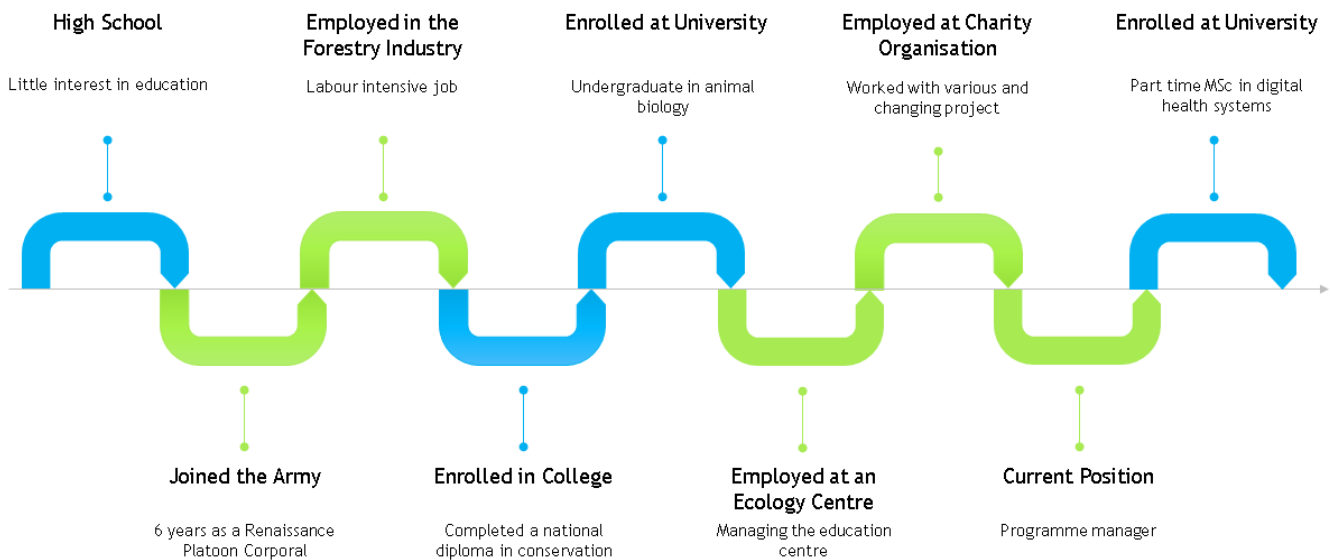


Health Data Analyst 4

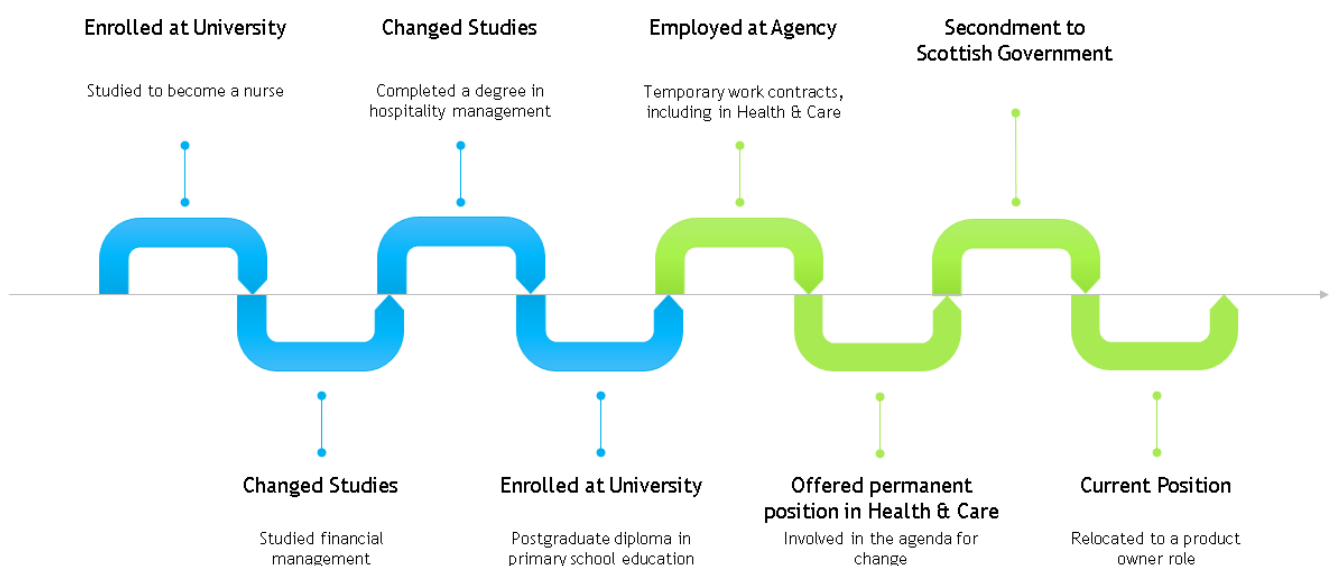


Appendix 2c: Career maps – Product Owners

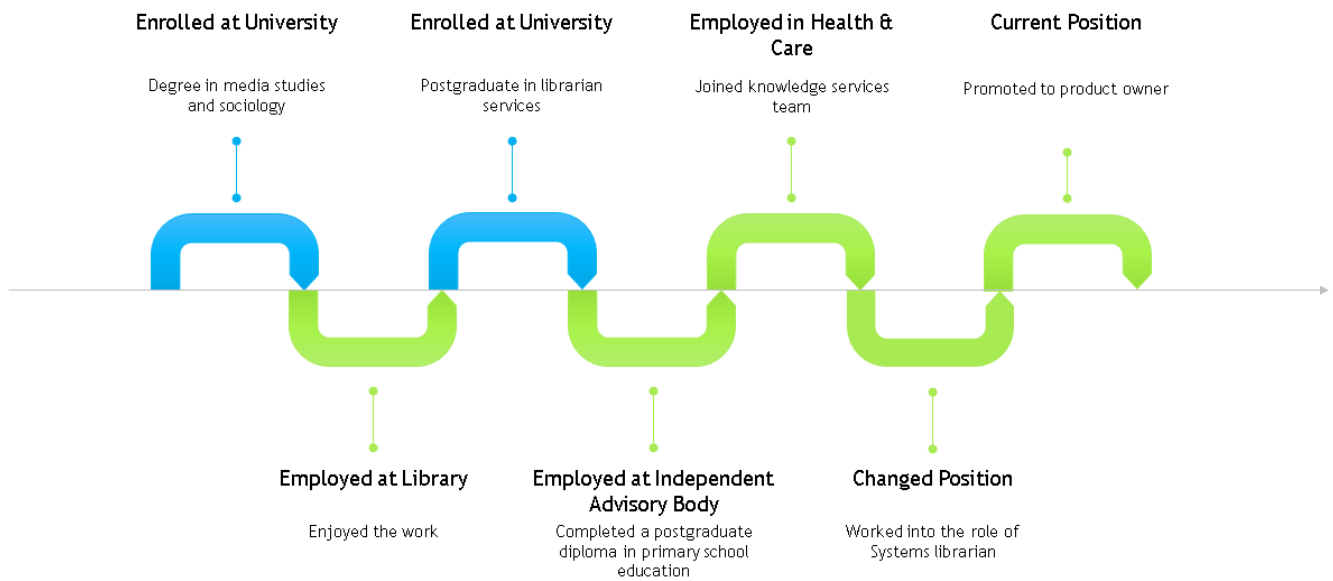
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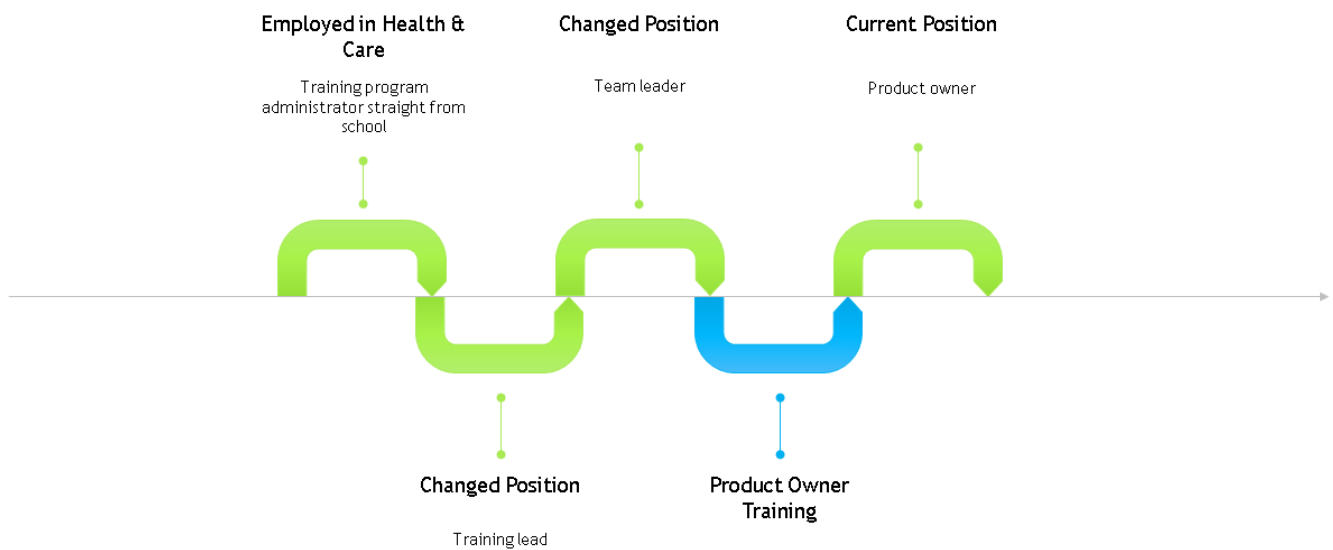
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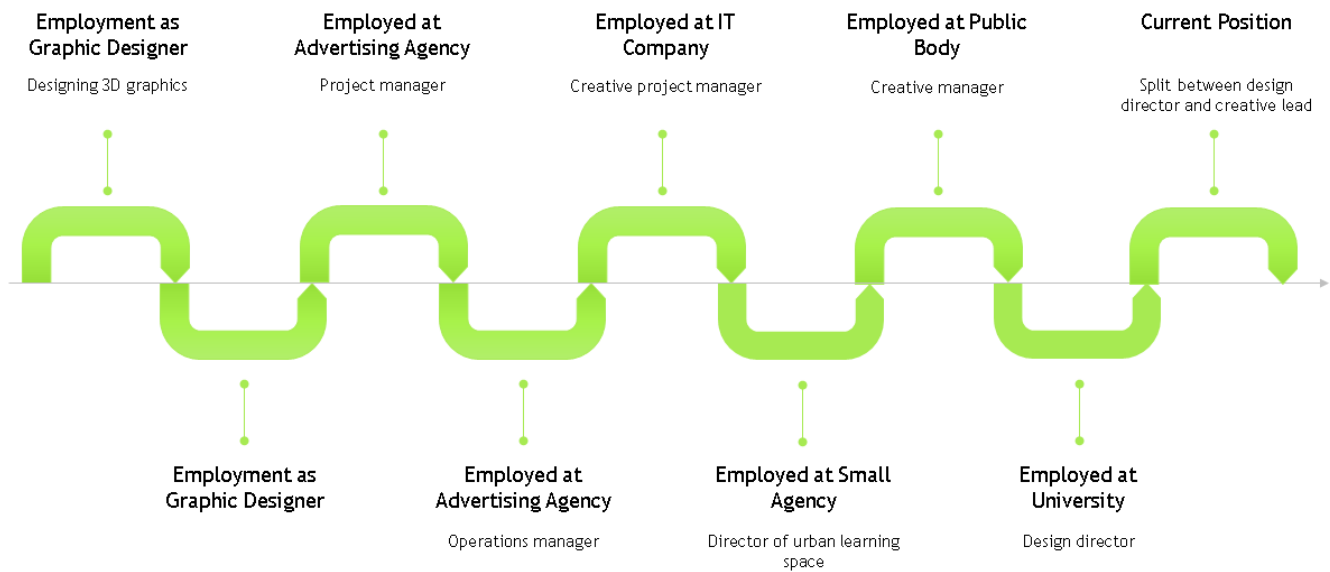
Product Owner 3



Product Owner 4



Product Owner 5

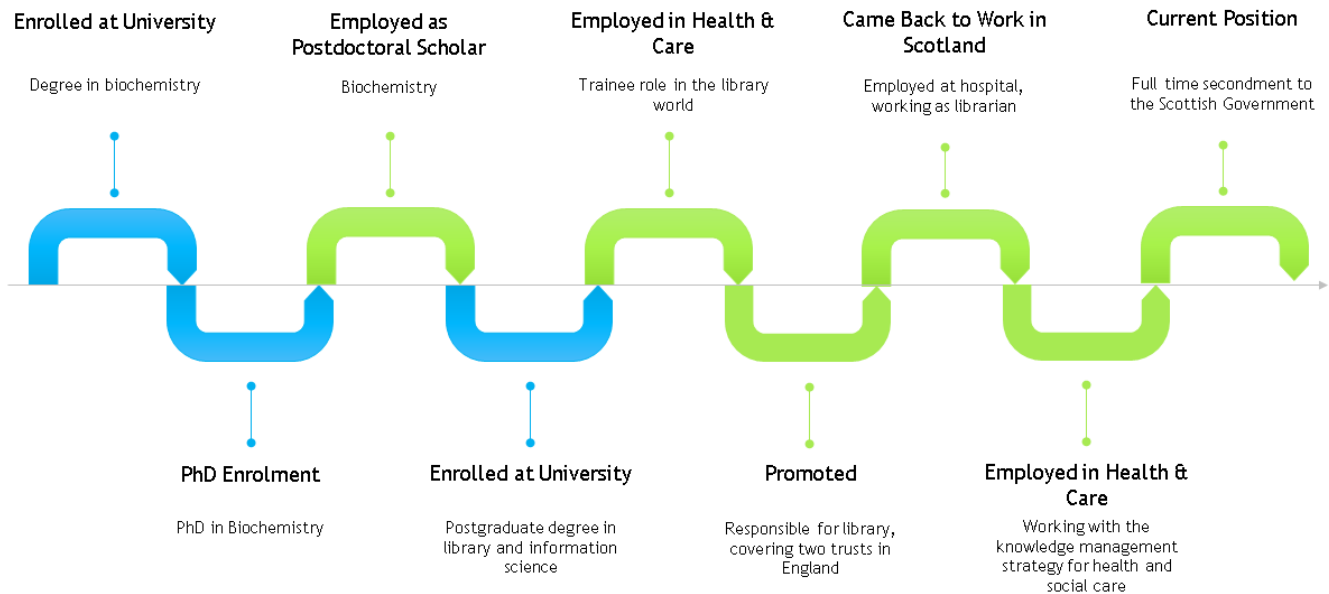


Product Owner 6

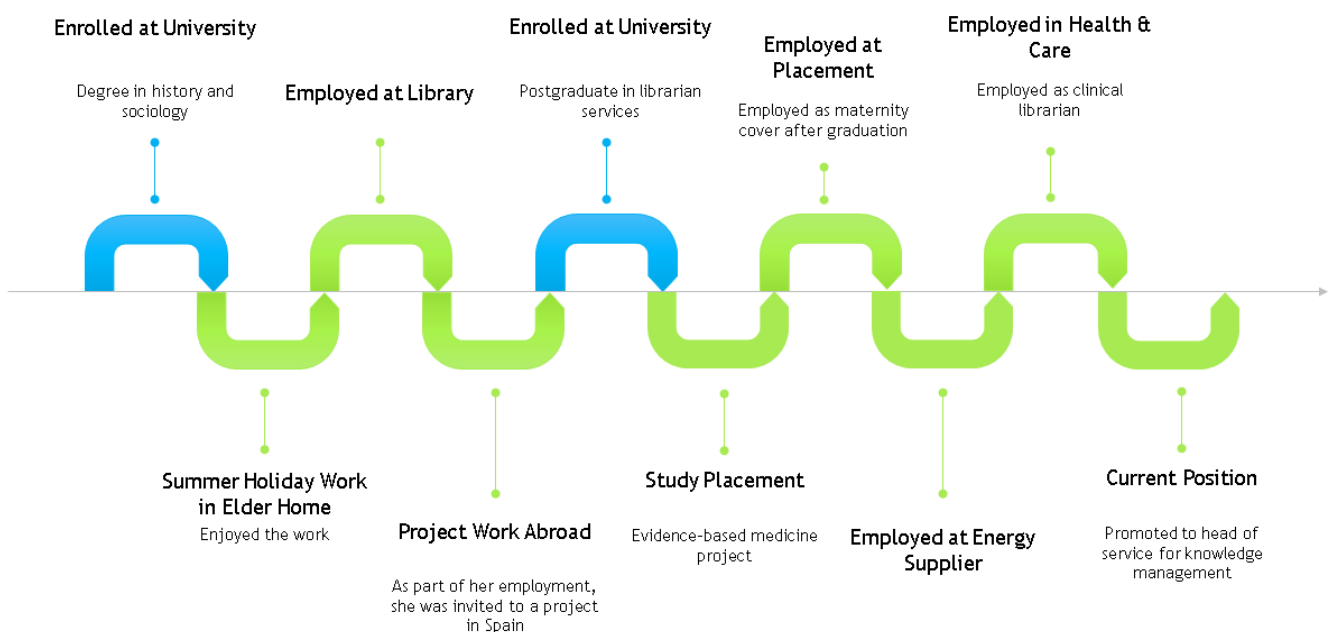


Appendix 2d: Career maps – Knowledge Engineers

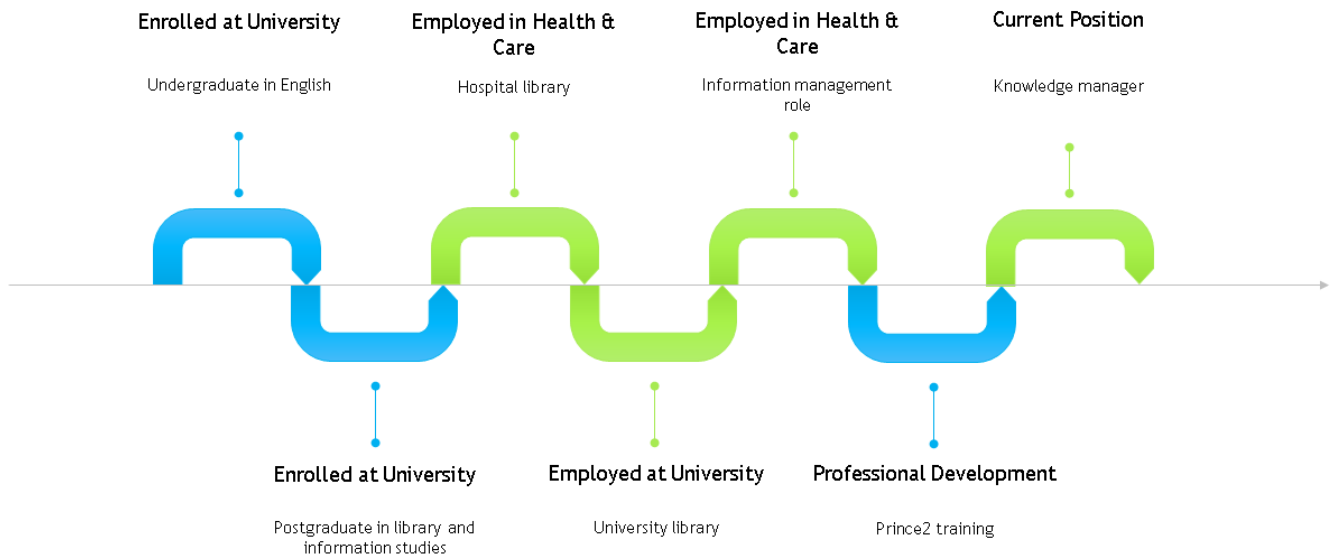
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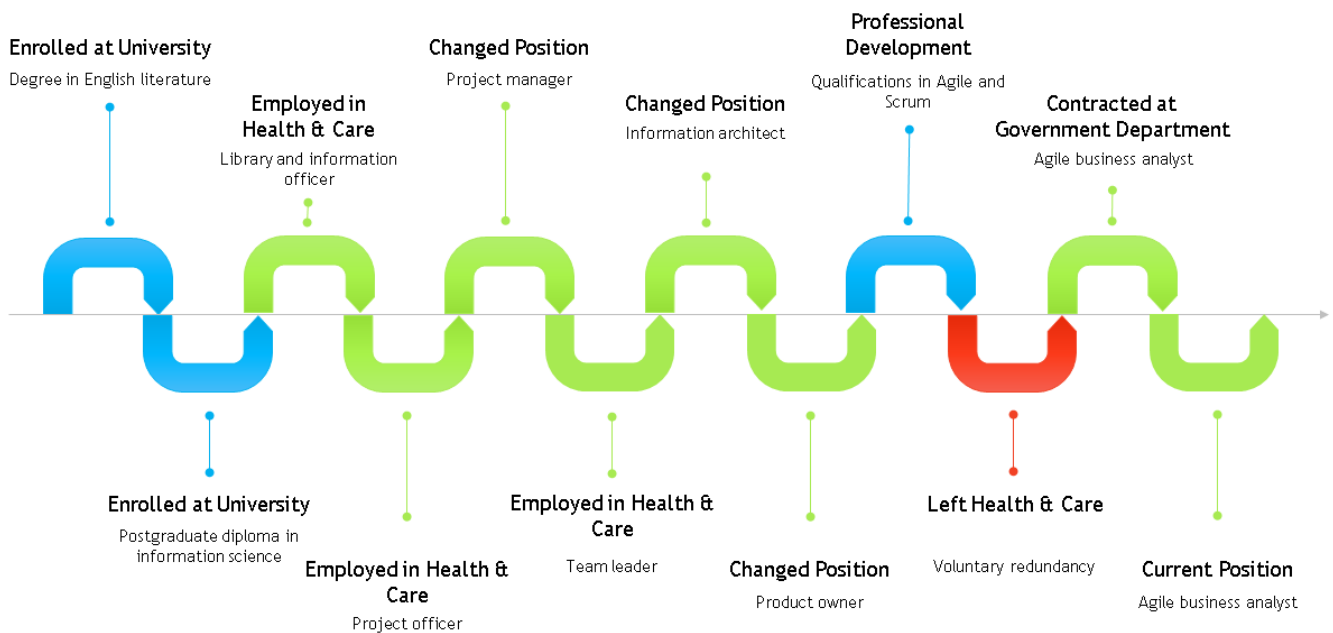
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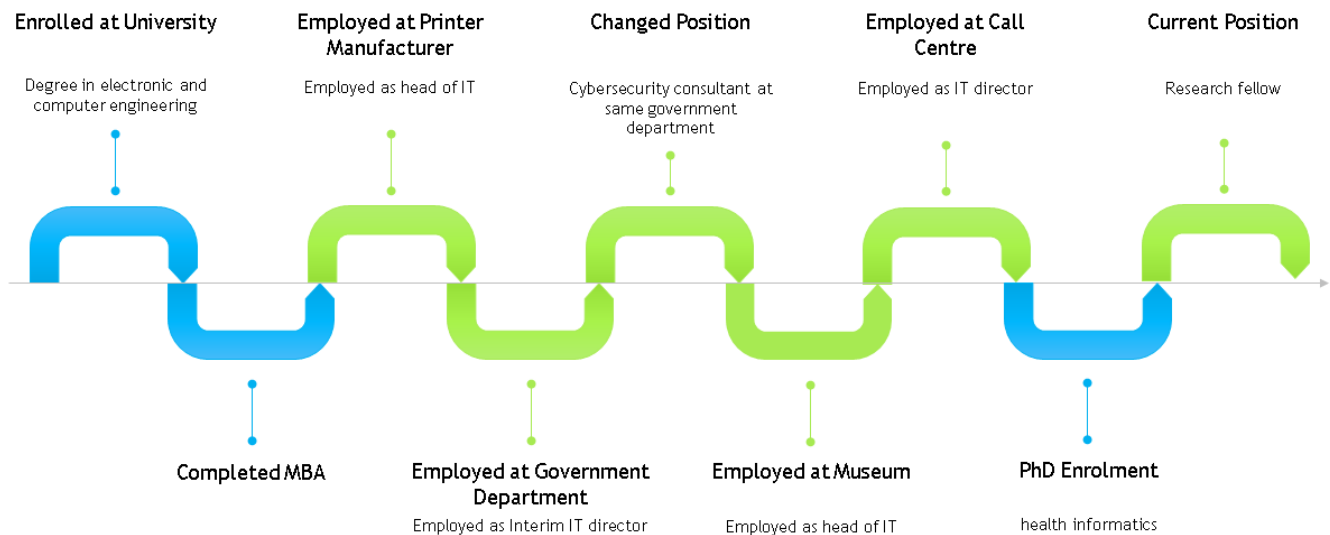
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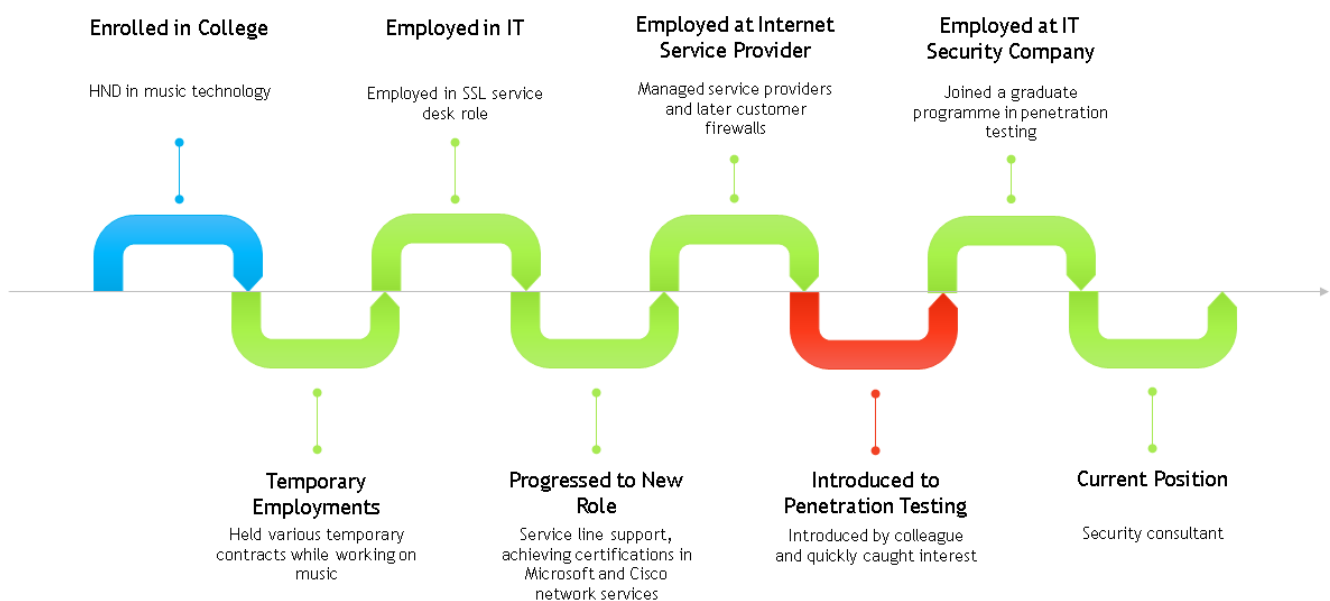
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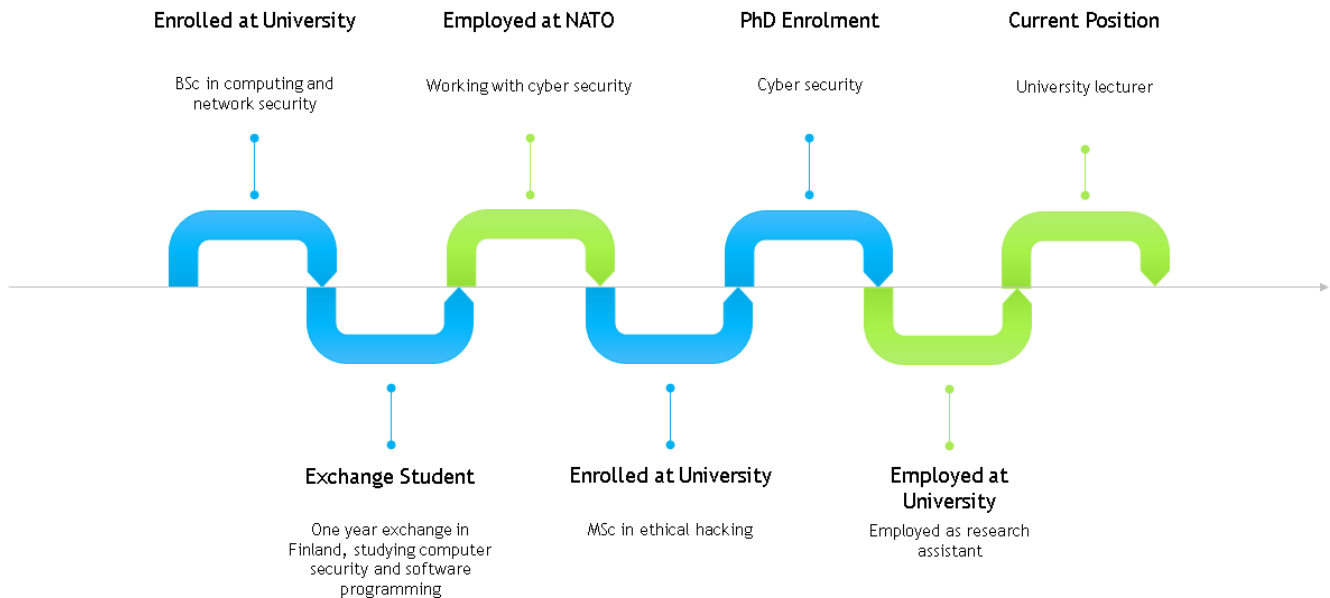
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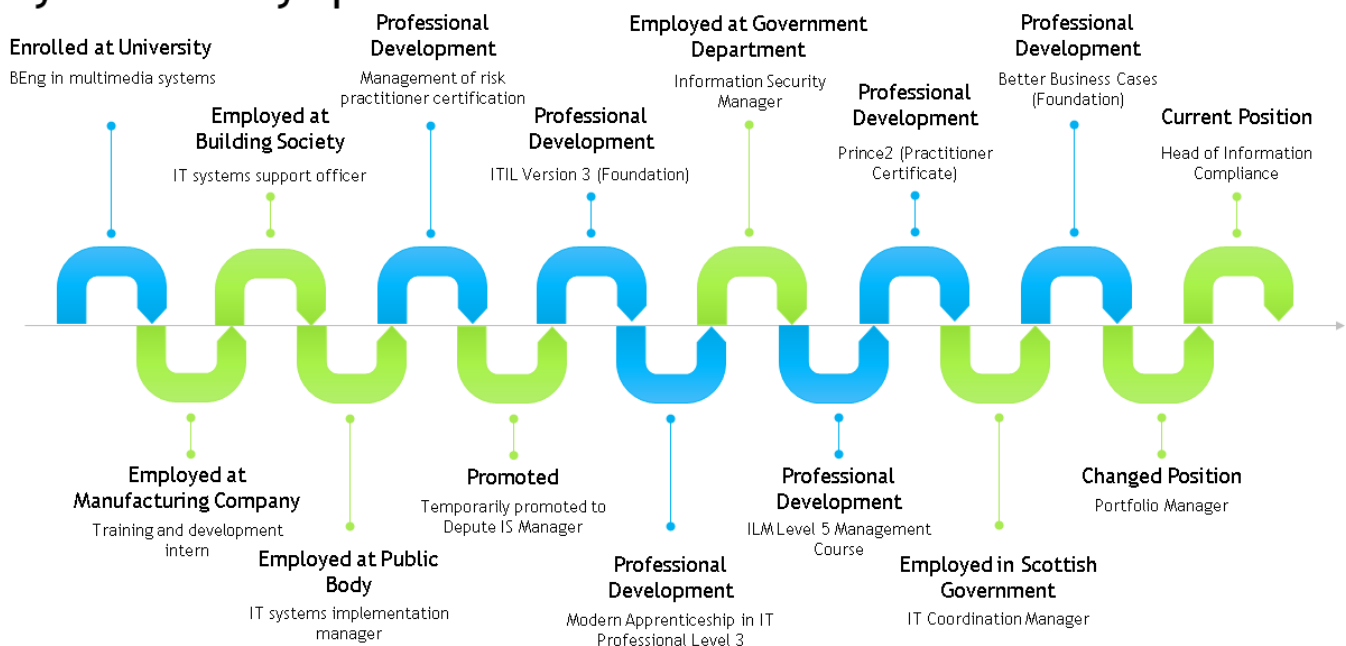
Cybersecurity specialist 2



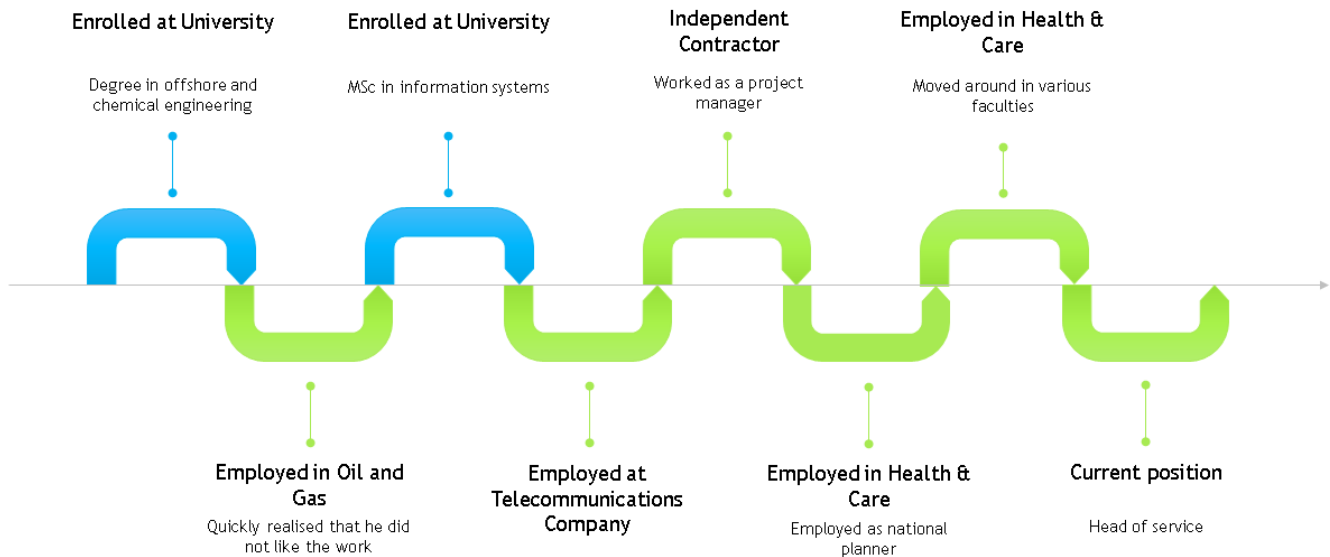
Cybersecurity specialist 3



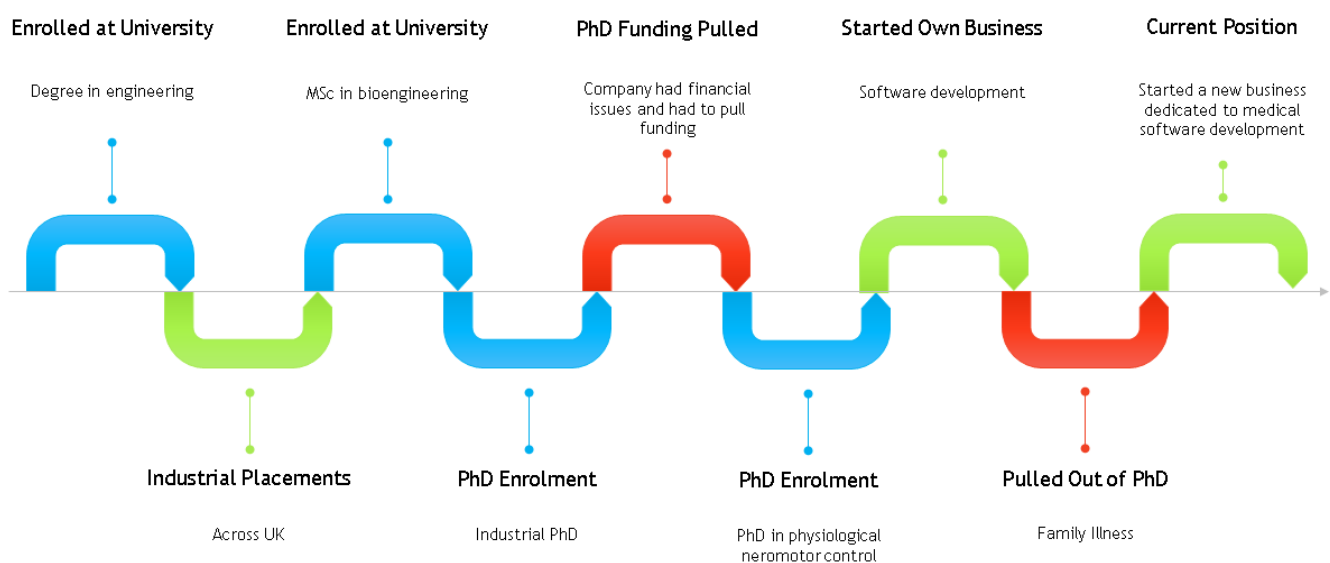
Cybersecurity specialist 4



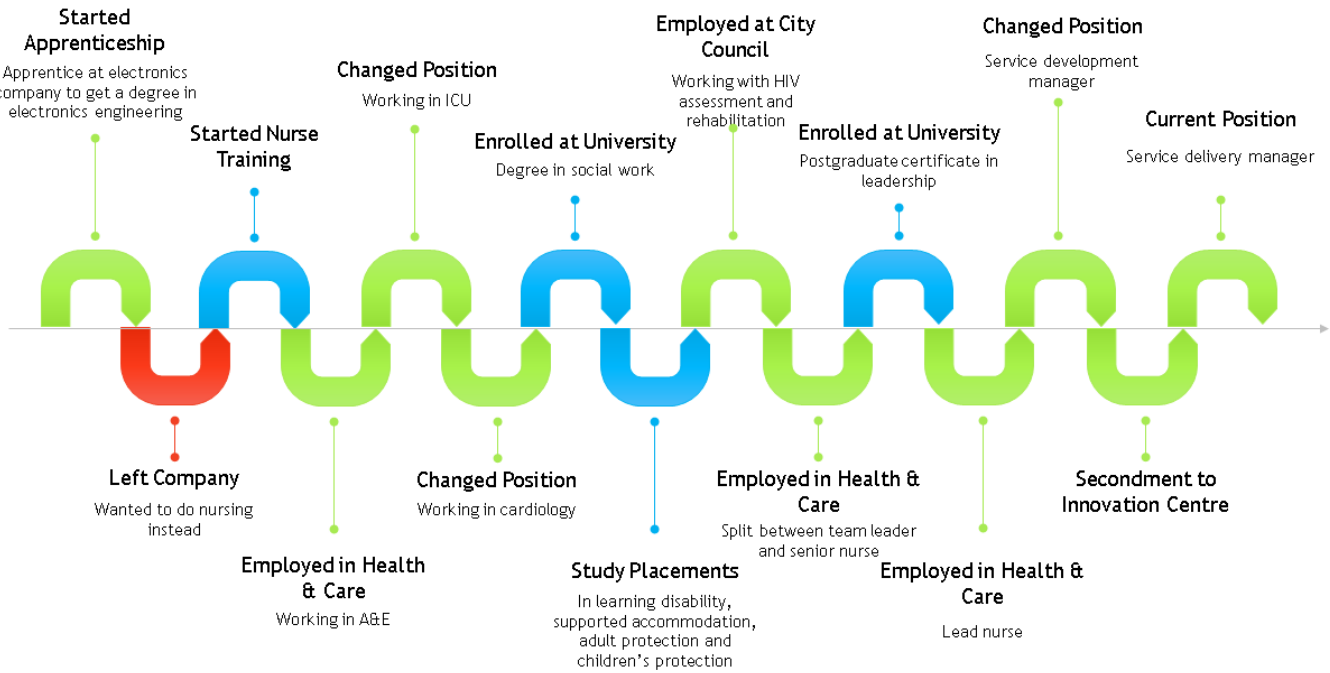
Implementation Facilitator 1



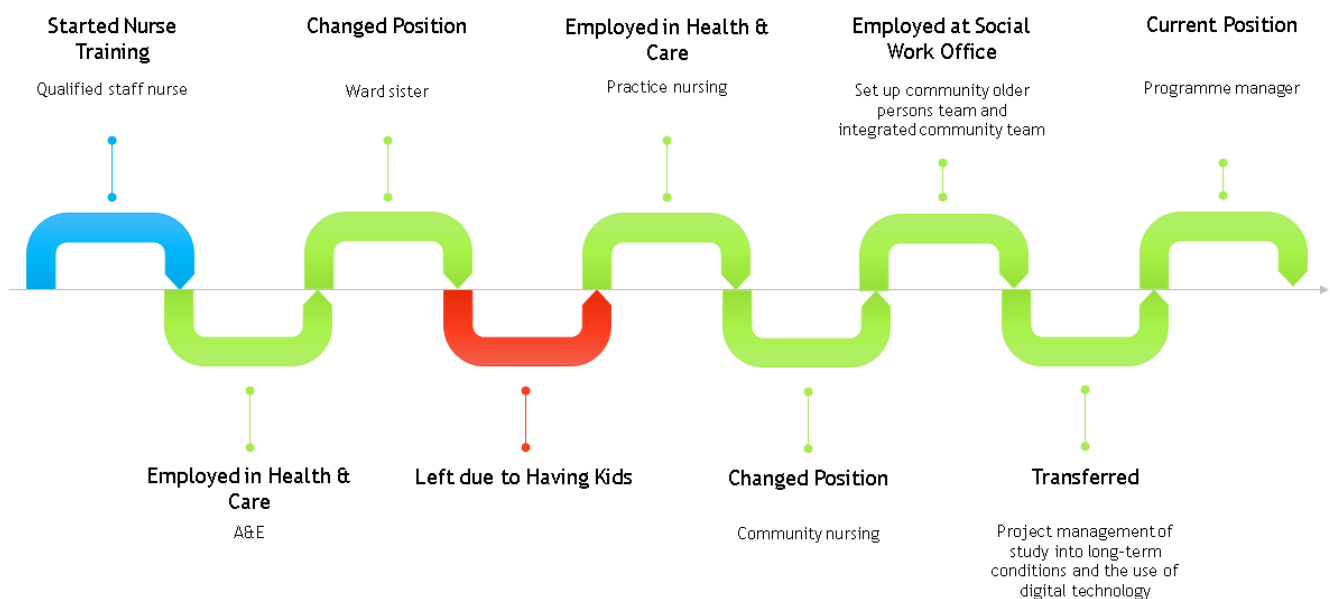
Implementation Facilitator 2



Implementation Facilitator 3



Implementation Facilitator 4



Appendix 3: Skills and Capabilities Framework - Discussion

Skills and Capabilities - definitions

The report focusses on skills, which we define as *the ability to apply knowledge and use know-how to complete tasks and solve problems* ^[1]. Skills encompass both cognitive (use of logical, intuitive, creative thinking) and practical (entailing manual dexterity, use of methods, materials, tools and instruments) capabilities (European Commission 2008; cf. Scottish Council for Development and Industry 2016) ^[43 & 44].

Competency is a broader concept than the term “skill”. It has been defined as “*an ability to use knowledge and skills with responsibility, autonomy and other appropriate attitudes to the context of work, leisure and learning*” ^[45 & 46]. It encompasses both knowledge and attitudes, which motivate for continued competent performance, as well as ethics, values and priorities. Competencies relate to current practices in known roles ^[46].

Capability, a future oriented concept, refers to *new and emerging professional challenges* and focusses on how to prepare to meet these ^[46].

It is useful to make a note of the distinction between competencies and capabilities as defined here to discuss the future skills needs. Given the fast pace of change in society and the work landscape, capabilities will map against what are deemed “21st century skills” or Skills 4.0 ^[10,11,12,13 & 47]. These are promoted as the set of core competencies that will help students and employees to thrive in the information age. There are various ways in which these skills are presented, but they share a core of what might be deemed “soft skills”.

21st Century skills

In broad terms, “21st century skills are not new, only newly important” ^[10]. Trilling and Fadell (2012) describe the 21st century skills as comprising of three main knowledge domains, these being ^[14]:

1. Innovative thinking (collectively referred to as Learning and Innovation, or the 4 C’s);
2. Information, media and ICT skills (collectively referred to as “digital literacies”);
3. Career and Life skills.

These are presented in the Table A3.1 with further granularity:

1. Learning and Innovation (the 4 C's)	2. Digital Literacy	3. Career and Life
Critical thinking and problem-solving	Information Literacy	Flexibility and adaptability
Creativity and Innovation	Media Literacy	Initiative and self-direction
Communication	ICT Literacy	Social and cross-cultural interaction
Collaboration		Productivity and Accountability
		Leadership and responsibility

Table A3.1: 21st Century skills (Source: Trilling and Fadell 2012)

Binkley et al. (2014) provide further definition to the learning and innovation skill set, or the Four C's, presented in Table A3.2 below ^[11]. According to them, *Critical thinking* consists of scientific reasoning, the ability to think on a systems level and computationally, and of decision making and problem solving. *Creativity* is about divergent and innovative thinking, originality, inventiveness and the ability to see failure as an opportunity to improve. *Collaboration* means the ability to work effectively and respectfully within diverse teams, to be flexible, being willing to compromise in order to accomplish goals, and having the ability to assume shared responsibility. Finally, *Communication* is the ability to articulate thoughts and ideas in a variety of ways for a range of purposes to diverse audiences in different environments, as well as the ability to use diverse types of media and technologies for communication purposes.

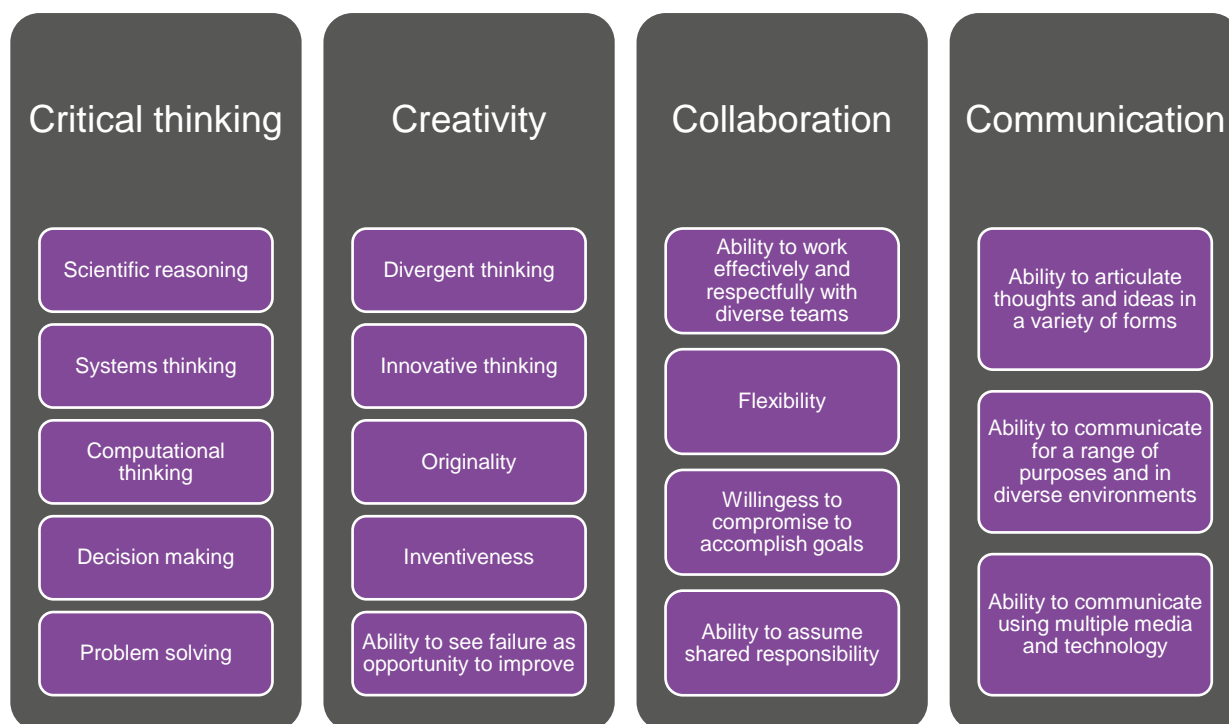


Table A3.2: Definition of 4 C's (Source: Binkley et al., 2014) ^[11]

The Four C's also appear on the World Economic Forums (2016) list of 10 skills that "help people to thrive in the 4th Industrial revolution" (see table A3.3 below) ^[4]. The WEF provides a comparison between skills required in 2015 and in 2020. The skills listed in the table map quite closely against the 21st Century skills discussed above:

In 2015	In 2020
1. Complex Problem Solving	1. Complex problem solving (=1)
2. Coordinating with Others	2. Critical thinking (+2)
3. People Management	3. Creativity (+7)
4. Critical thinking	4. People Management (-1)
5. Negotiation	5. Coordinating with Others (-3)
6. Quality Control (out in 2020)	6. Emotional Intelligence (new)
7. Service Orientation	7. Judgement & Decision Making (+1)
8. Judgement and Decision Making	8. Service Orientation (-1)
9. Active Listening (out in 2020)	9. Negotiation (-4)
10. Creativity	10. Cognitive Flexibility (new)

Table A3.3: World Economic Forum comparison of skills that help people to thrive in the 4th industrial revolution. Source: adapted after World Economic Forum (2016) ^[4]. Future of Jobs Report (Gray, A., 2016; Desjardins 2018) ^[12 & 13]

Both the 2015 and 2020 lists have retained *complex problem solving* as the key skill, but *critical thinking* and *creativity* have risen strongly into the top three skills required in 2020: creativity by seven steps from the 10th place to the 3rd, and critical thinking jumping up from 4th place to the 2nd.

The 4th Industrial revolution entails accelerating digitisation and automation of the world of work. In this context, the distinctly human skills and abilities increase in importance. While computers and AI can quickly solve problems that would be impossible or cumbersome for humans to address, humans are able to approach very complex or poorly defined problems in creative and critical ways that computers cannot.

We are able to access and search for information from diverse sources, including non-digital ones; humans can imagine a variety of solutions to problems and test these out. We can come up with and combine unexpected, abstract ideas and diverse pieces of information; we can deal with ambiguity; think of diverse interpretations to questions, and reason backwards to find a solution in a way that computers are not able to [4, 13 & 47].

Emotional intelligence and *cognitive flexibility* are new entrants on the list. The skill for *active listening* has fallen out of the Top 10, but emotional intelligence is a skill that incorporates active listening skills and more, it is the ability to read people and situations correctly, to display empathy. This is a distinctly human ability, as is cognitive flexibility – the ability to adjust oneself to ever-changing work situations and environments.

Coordinating with others (or collaboration) is still important but being left behind the top four of problem-solving, critical thinking, creativity and *people management* (which has come down by one point since 2015). *Negotiation skills* (which could denote the broader concept of communication of the Four C's) have fallen in importance from 5th to the 9th position, which is contrary to the importance given to it in the 21st Century division (see above, Table A3.1). *Service orientation* and *people management* have swapped 7th and 8th positions, with *quality control* in 6th place in 2015 being removed from the Top 10 entirely for skills required in 2020.

A Future of Jobs Survey by the World Economic Forum (2018) has a more recent comparison of Top 10 Skills demand for 2018 and 2022 [4]:

Today - 2018	Trending - 2022
1. Analytical thinking and innovation	1. Analytical thinking and innovation (=1)
2. Complex problem-solving	2. Active learning and learning strategies (+2)
3. Critical thinking and analysis	3. Creativity, originality and initiative (+2)
4. Active learning and learning strategies	4. Technology design and programming (new)
5. Creativity, originality and initiative	5. Critical thinking and analysis (-2)
6. Attention to detail, trustworthiness	6. Complex problem-solving (-4)
7. Emotional intelligence	7. Leadership and social influence (+2)
8. Reasoning, problem-solving and ideation	8. Emotional intelligence (-1)
9. Leadership and social influence	9. Reasoning, problem-solving and ideation (-1)
10. Coordination and time management	10. Systems analysis and evaluation (new)

Table A3.4: comparison of top 10 skills in 2018 and 2022. (Source: WEF 2018) ^[4]

Although this report was also produced by the World Economic Forum, this one was based on a slightly different approach to skills than the 2015 report. There are some categories which are named similarly to the 2015 report, these are more comprehensive in the 2018 report ^[4]. The most noteworthy thing about this comparison is the appearance of *Active learning and learning strategies* category, which doesn't feature at all in the 2015-2020 comparison above (see table A3.3). This, indeed, is a core competency for the future.

Furthermore, this table places a strong emphasis on technological skills: *Technology design and programming*, and *systems analysis and evaluation* are new skills on the 2022 Top 10 and reflect the accelerating pace of digital transformation of society. The other desired skills in the 2022 list are the aforementioned human specific abilities, such as innovation, creativity, critical thinking, complex problem-solving, emotional intelligence, leadership and social influence and ideation.

Meta-skills

Skills Development Scotland (2018) has also carried out a skills review for the future, "Skills 4.0" ^[47]. This review strongly echoes the 21st Century skills, and SDS (2018) has named these *meta-skills*, which are "timeless, higher order skills that create adaptive learners and promote success in whatever context the future brings" (p.8).

Again, these skills are not new, but their importance in the society is growing. Meta-skills are presented below in table A3.5:

Self-Management: "manage the now"	Social Intelligence: "Connect with the world"	Innovation: "Create our own change"
Focussing	Communication	Curiosity
Integrity	Feeling	Creativity
Adapting	Collaboration	Sense-making
Initiative	Leading	Critical thinking

Table A3.5: Meta-skills (Source: Skills 4.0 -report by Skills Development Scotland,2018) ^[47]

In addition to these three sets of meta-skills, SDS (2018) also listed a number of universal skills, which are seen as fundamental to success within the world of work in the future. These are literacy, numeracy and digital intelligence. Digital intelligence, according to this report, takes two forms: it is either the confidence to use and exploit technology and the ability to grasp new technology as it emerges and work alongside machines, or the ability to create brand new technology.

Skills for Information Age (SFIA)

In terms of skills taxonomies, there is also the very well-established Skills for Information Age (SFIA) framework, currently in its 7th ^[15]. This is an extensive and thorough presentation of the digital and information technology skills and competencies used globally by businesses and organisations. It has seven levels of responsibility characterised by generic attributes, along with many professional skills and competencies described at one or more of said levels. These are presented below in Table A3.6:

Level 7	Set strategy, inspire, mobilise
Level 6	Initiate, influence
Level 5	Ensure, advise
Level 4	Enable
Level 3	Apply
Level 2	Assist
Level 1	Follow

Table A3.6: Seven competency levels of the SFIA framework (Source: SFIA, 2018a) ^[15]

The SFIA standard “covers the full breadth of the skills and competencies related to information and communication technologies, digital transformation and software

engineering”, something that many of the occupational categories in our study fall within ^[15]. The 2018 update focussed on software engineering, cyber security, digital transformation, agile and DevOps, Big Data, informatics and knowledge as their special themes. The framework provides a shared language and a standardised way of assessing skills requirements for the workplace.

While the framework is widely used and globally recognised, using it as the basis of analysis for the data in this report was not feasible or meaningful. The skills categorisations in this study were derived from gathered data, where insights generated by the interviewed representatives were based on questions such as “what would you be looking for in a person that you would wish to employ to do this job?”. Many of the key skills and capabilities named during the interviews were judged to be *soft skills*, whereas the SFIA framework is strongly based on *professional skills*, such as “information governance” or “network design” (for a full list of skills, please see SFIA Foundation, 2018b) ^[48]. The SFIA 7 framework presents a lot of the soft skills under two broader categories “Business skills” and “Complexity”, which is not sufficiently granular a division for presenting our data. Furthermore, while some of the professional skills listed in the framework are applicable to the six occupational categories, the data set is not extensive enough to cover all seven skills levels of the framework.

The SFIA framework is more useful for employers in assessing the skills requirements in the workplace, when planning to recruit staff and in drafting job descriptions, or even for education providers when developing courses. The existing standards will help in the discussion of educational pathways for some of the occupational categories investigated in this study, but this would be seen as a goal rather than something we can aspire to align with at this stage of the small study.

An example of a skills framework by SFIA is available in Image A3.1 ^[15]:

		1 Follow	2 Assist	3 Apply	4 Enable	5 Ensure, advise	6 Initiate, influence	7 Set strategy, inspire, mobilise
Strategy and architecture	Information strategy					Enterprise IT governance GOVN		
						Strategic planning ITSP		
						Information governance IRMG		
							Information systems coordination ISCO	
						Information security SCTY		
	Advice and guidance					Information assurance INAS		
						Analytics INAN		
						Data visualisation VISL		
						Information content publishing ICPM		
						Specialist advice TECH		
	Business strategy and planning					Consultancy CNSL		
						Demand management DEMM		
						IT management ITMG		
						Financial management FMIT		
						Innovation INOV		
	Technical strategy and planning					Research RSCH		
						Business process improvement BPPE		
						Knowledge management KNOW		
						Enterprise and business architecture STPL		
						Business risk management BURM		
						Sustainability SUST		
						Emerging technology monitoring EMRG		
						Continuity management COPL		
						Network planning NTPL		
						Solution architecture ARCH		
						Data management DATM		
						Methods and tools METL		

Image A3.1: SFIA skills categories for strategy and architecture (Source: SFIA Foundation, 2018a) ^[15]

Appendix 4: Updated Digital Health and Care Market Analysis

The Digital Technology sector, within which the Digital Health and Care sector sits, is among the fastest expanding economic sectors globally. There are more statistics available of the wider Digital Technology sector than Digital Health and Care, but these are largely applicable to the latter as well. This section with section 2.3, will provide an updated market overview of the Digital Health and Care sector detailed in our 2018 report.

In 2015, the global digital transformation⁸ market was valued at 150bn USD and is predicted to increase in value to \$431.7bn by 2021. This represents a market growth at 19.2% global cumulative annual growth rate (CAGR) between 2016-21^[49]. The global Digital Healthcare market is predicted to exceed \$504.4bn by 2025 ^[50]. The UK market size for Digital Health was valued at \$4bn in 2017 and with adoption of larger digital solutions will continue to grow in years to come ^[51]. The NHS's IT market is predicted to reach £4bn by 2022 ^[52].

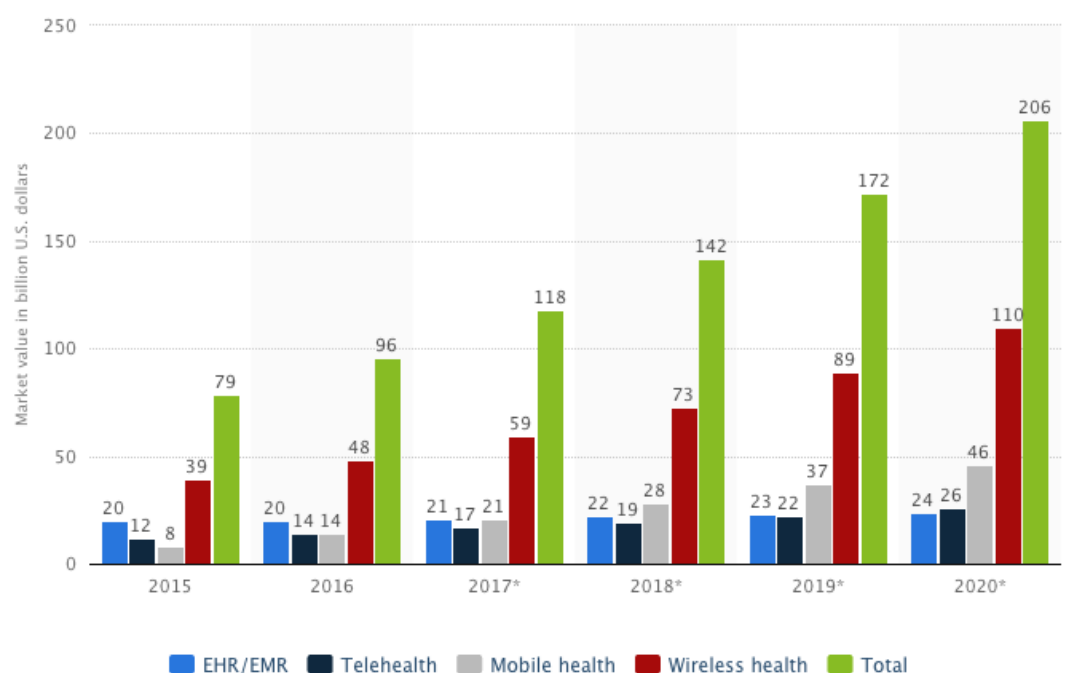
In the UK, the Digital Technology economy⁹ was creating jobs 2.8 times faster than the wider economy in 2016 and was still over 2.6 times as fast as the rest of the economy in 2018 ^[9 & 53]. The same trend is evident in Scotland, where the Digital Technology sector is the fastest growing economic sector over all, predicted to expand twice as fast as the rest of the Scottish Economy until 2024 ^[54]. The number of digital technology businesses has increased by over 53% since 2010 in Scotland, currently employing over 60,000 people in total. The demand for ICT specialists is particularly high. This has been exemplified in the need for computer consultancy increasing by 72%, and for programmers by 152% since 2010 ^[55]. In 2015-16, 90,000 people were employed as technology professionals across *all sectors*, accounting for 4% of the national workforce in the country. Approximately 60% of the workforce was employed in technology roles and 40% in other types of jobs ^[56]. In 2015 the sector contributed £3.9bn Gross Value Added (GVA) to the Scottish economy ^[56].

The Scottish ICT sector is projected to require 12,800 new employees per year until 2020 to satisfy the need for a sufficiently skilled workforce ^[56]. The Scottish government's ambitions are even higher as they aim to create 150,000 new Digital Technology roles across Scotland over the next five years ^[57]. The expansion of the Digital Technology sector is creating significant employment opportunities for skilled

⁸ Digital transformation market refers to the use of digital technologies such as cloud computing, Big Data, social media, mobility, analytics, and more – all key components of digital health - to improve or add more features to their traditional business processes and also to maintain customer relationships. Digital transformation is the outcome of changes that occur with the application of advanced digital technologies ^[49].

⁹ TechCity defines digital technology business as one that provides digital technical services / products / platforms / hardware, or heavily relies on these, as its primary source of revenue ^[9].

workers, young people and other new entrants to the field ^[56]. These same trends are also reflected within the Digital Health sector.



© Statista 2017

Figure A4.1: The growth of the digital health Market. Source: Statista ^[48].

Figure A4.1 displays the global Digital Health market by major segment¹⁰ in 2015 and 2016, with a projection from 2017 until 2020 ^[58]. Statista valued the global Digital Health market at 80bn USD in 2015, expecting that it will exceed 200bn USD by 2020. This growth will be driven primarily by the mobile and wireless health markets ^[58].

The job market in the Digital Technology and Digital Health sectors (update)

In 2017, Company Connecting listed 139 IT companies active within the Healthcare sector in Scotland ^[59]. The majority of these (77) were located either in Glasgow or in Edinburgh, where the strongest growth has taken place ^[60]. Most of these Digital Health and Care companies are either small or medium size enterprises employing just 2-5, or 20-49 staff - a trend seen across the UK ^[59]. According to the report by Scottish Development International, companies with a specific focus on digital health

¹⁰ The way that the digital health sector is segmented varies from one source to another.

and care in Scotland employ a total of 7000 people combined^[61]. Differences in numbers reflect the varying ways that the Digital Health sector has been defined¹¹.

In 2016, the Digital Technology sector accounted for 1.56 million jobs in the UK, and for 1.64 million in 2017. Over 60,000 people are employed in technology businesses across Scotland, making up 2% of the national workforce. Almost two thirds of this workforce hold technical roles. The number of people choosing to work in Digital Technology businesses has grown in the central belt of Scotland in recent years with Glasgow and Edinburgh seeing 36% and 19% increases respectively. The number of technology professionals employed in other industries is growing faster than those employed within technology businesses themselves, this illustrates the demand for digital skills across Scotland and the importance of digital technology professionals for the economy^[56].

The average salaries within the Digital Tech sector were higher than the UK's national advertised average in 2018 with £42,578 compared to £32,477^[53]. A similar trend is visible in Scotland with an average technology sector salary being at least 30% higher than the Scottish average and growing at a faster rate than salaries in other sectors^[60].

¹¹ Company Connecting was looking specifically at IT companies active within the Digital Health sector (2017), while Deloitte (2015) divides the sector into four areas: telehealthcare, mHealth, Health Analytics and Digitised health systems. For a more detailed description, see above p. 17-18^[59 & 62].

Appendix 5a: Full Skills and Capabilities Table for Software Developers

21 st Century Skills Plus	Capabilities and knowledge required as per data	Importance
Technical IT-skill (Advanced ICT literacy assumed)	<ul style="list-style-type: none"> Relevant technical competency in-depth knowledge of computer systems and technologies. 	C
Coding/ programming	<ul style="list-style-type: none"> In-depth knowledge of programming languages. (SQL the most useful for the NHS; R and Python, others). 	C
Design	<ul style="list-style-type: none"> Software design skills; Appreciation of what is good design. 	C
End-user engagement	<ul style="list-style-type: none"> Engaging with end users Ability to elucidate user requirements and translate these into technological solutions. 	C
Advanced information literacy Systems analysis and evaluation; Quality improvement	<ul style="list-style-type: none"> Awareness of current issues affecting the industry and its technologies. Ability assess the robustness of the software/system being developed. 	I
Critical thinking, complex problem-solving and analysis	<ul style="list-style-type: none"> Excellent problem-solving skills; Critical, logical and analytical thinking A logical, analytical and creative approach to problems; Investigative skills Systems-thinking: ability to see a project as a whole and break it up in smaller chunks 	I
Creativity, originality and initiative	<ul style="list-style-type: none"> Creativity in design and problem-solving 	I
Communication	<ul style="list-style-type: none"> Excellent communication skills: <ul style="list-style-type: none"> The ability to communicate with clients, colleagues and management to explain complex issues clearly and concisely; The ability to listen carefully to be able to elucidate the right requirements; ability to listen to people and take notes 	I
Emotional intelligence	<ul style="list-style-type: none"> Ability to get on with different types of people from different backgrounds and professions as part of the team and in your day-to-day work; Empathy. 	I
Organisational skills; Productivity and accountability	<ul style="list-style-type: none"> A meticulous and organised approach to work Thoroughness and attention to detail 	I
Collaboration	<ul style="list-style-type: none"> The ability to work both in a team and alone and to manage your own workload 	I
Active learning and learning strategies	<ul style="list-style-type: none"> Ability and desire to learn quickly; Enquiring mind 	I

	<ul style="list-style-type: none"> Curiosity 	
Cyber security (Knowledge and Skills; specialist)	<ul style="list-style-type: none"> Cyber Security – enough understanding of the issues to take cyber security aspects into account in your work. 	I
Project management skills	<ul style="list-style-type: none"> Ability to see project through 	I
Business skills and Awareness	<ul style="list-style-type: none"> Business skills and commercial awareness 	W
Domain specialism	<ul style="list-style-type: none"> Basic understanding of the Health and Care setting required. 	B
Not mentioned for this category	<ul style="list-style-type: none"> Research, data, analysis, analytical skill Facilitation skills Change management Training skills 	NA
Personal attributes	<ul style="list-style-type: none"> Need to be focussed and disciplined; Analytic approach to work; Adaptability 	

Appendix 5b: Full Skills and Capabilities Table for Product Owners

21 st Century Skills Plus	Capabilities and knowledge required as per data	Importance
Domain specialism	<ul style="list-style-type: none"> An in-depth understanding of the subject domain; Understanding of user's needs (individually and on a systems level) absolutely essential. <p><i>"Product owner needs to understand the software that they are using but more importantly they need to understand the needs of the users that will be using this software."</i></p>	C
Communication	<ul style="list-style-type: none"> Excellent communicator: <i>"The top skills I need to be a good Product Owner is communication. I have to be able to listen to user expectations and work with national directorates as well as prioritise the needs of the users."</i> Brokering – the ability to translate information between teams with different expertise and levels of understanding. Negotiation skills, active listening Explain what users need to the developers Communicate between the users and the developers 	C
Emotional intelligence	<ul style="list-style-type: none"> Diplomacy, patience, resilient, able not to take things personally Ability to get on with a wide variety of people and personalities. Resilience; Thick-skinned Flexibility and adaptability 	C
End-user engagement	<ul style="list-style-type: none"> Elucidate user requirements - help users understand what the software can do for them, and what they can request of the developers; Engaging with end users 	C
Advanced ICT literacy	<ul style="list-style-type: none"> Sufficient technical understanding of the software being developed, its affordances and functionality 	I
Advanced Information literacy	<ul style="list-style-type: none"> A Product Owner needs to understand what the tech does but not necessarily <i>how</i> it does it. 	I
Facilitation Skills	<ul style="list-style-type: none"> Ability to manage expectations against reality; Strong aptitude to people skills; Have confidence to make decisions; Prioritise needs and actions effectively; 	I
Project management skills	<ul style="list-style-type: none"> Project management skills and experience are vital – Agile preferred over PRINCE2 (too rigid). 	I
Organisational skills; Productivity and accountability	<ul style="list-style-type: none"> Excellent organisational and time management skills (timelines and diaries) 	I
Leadership and social influence	<ul style="list-style-type: none"> Authority to make decisions in the project Ability to prioritise user needs and activities 	I

Critical thinking, complex problem-solving and analysis	<ul style="list-style-type: none"> Analytical skills; ability to drill down a problem; Critical thinking; Problem-solving 	I
Creativity, originality and initiative	<ul style="list-style-type: none"> Ability to think of new ways to do things Thinking outside the box; <i>“That kind of design thinking kind of approach where you need to be able to understand not what just presents but the opportunities around it.”</i> 	I
Business skills and Awareness	<ul style="list-style-type: none"> The Product Owner has the business view of the software. <p><i>“The software that is developed will have a variety of different users and so the Product Owner needs to know what exactly the system is going to deliver and the value it is expected to bring to the users. So, this involves surveying what the organisation’s priorities are and following that into the business process and the prioritisation of activities.”</i></p>	I
Active learning and learning strategies	<ul style="list-style-type: none"> Analytical mindset; a ‘growth mindset’ or a willingness to grow and develop oneself 	I
Active learning and learning strategies	<ul style="list-style-type: none"> Ability and desire to learn quickly; Enquiring mind Curiosity 	I
Collaboration	<ul style="list-style-type: none"> Ability to work in collaboration with a wide variety of people from different professional and socio-cultural backgrounds. 	I
Change management	<ul style="list-style-type: none"> POs role carries an aspect of change management 	W
Technology design	<ul style="list-style-type: none"> Understanding of good design looks like, and what works for the users. 	W
Systems analysis and evaluation; Quality improvement	<ul style="list-style-type: none"> Working awareness of systems analysis and evaluation processes and quality improvement aspects of the software project. 	W
Cyber security (Knowledge and Skills; specialist)	<ul style="list-style-type: none"> Cyber Security – enough understanding of the issues to take cyber security aspects into account in your work. 	W
Technical IT-skills Coding/programming languages	<ul style="list-style-type: none"> Advanced IT-literacy is sufficient; basic understanding of technical IT issues Basic understanding of what coding and programming languages are can do. 	B
Not mentioned for this category	<ul style="list-style-type: none"> Research, data analysis, analytical skill Training skills 	NA

Appendix 5c: Full Skills and Capabilities Table for Implementation Facilitators

21 st Century Skills Plus	Capabilities and knowledge required as per data	Importance
Communication	<ul style="list-style-type: none"> Ability to communicate effectively, listen and take onboard user concerns; Ability to drill into questions to gain an understanding of users' needs and concerns; Good negotiation skills; Ability to translate users' concerns and needs for the development team and what is possible to achieve with the software for Awareness raising and validation of the software: ability to explain what its purpose is, what its limitations are, why trust it. <i>"Again, it's around being open to new ideas, to being adaptive and not being fixed in where you THINK it should be going. And listening and engaging with others. You need negotiating skills and listening skills, you really need to be watching the non-verbal cues, to understand what is actually being said, what people are doing or not doing around that and really to understand that".</i> 	C
Domain specialism	<ul style="list-style-type: none"> In-depth understanding of domain critical to the role. This could also mean having a technology background, should the project require that. <p><i>"But you'd need to have experience of Health and social care, it's really hard to catapult someone in who doesn't actually understand the landscape."</i></p>	C
Critical thinking, complex problem-solving & analysis	<ul style="list-style-type: none"> Ability for complex problem-solving on daily basis as part of the implementation process; Dealing with emergent problems and barriers in a timely manner. 	C
Systems analysis and evaluation + Quality improvement	<ul style="list-style-type: none"> Ability to carry out formative evaluation and iterative quality improvement of the software from design to the roll-out; Testing of the software in real, live environment; gathering feedback, ironing out usability and workflow or tech issues; Measuring the impact, gathering stats of usage, changes taking place in practice. Evaluation skills – ability to identify problems, really pin these down, and evaluate the overall impact of the innovation. 	C
Change management skills	<ul style="list-style-type: none"> Understanding software (or any other innovation) implementation as a process of change and having the ability to manage that change process among the wide variety of stakeholders. Ability to foresee the impact the innovation will have on e.g. the system and people's work practices, and to prepare people and systems for these changes so that the change is least disruptive. 	C
Emotional intelligence	<ul style="list-style-type: none"> Emotional intelligence and social skills are vital for an Implementation Facilitator; Diplomacy in engagement and empathy with the users; Thick skin. 	C

Facilitation skills	<ul style="list-style-type: none"> Managing facilitation of the project on behalf of the partnership "Because what is very crystal clear, we have no management power over anybody, so we can't pull the management card. We're always pulling on the negotiation, encouragement, motivation, future vision, trying to buy people into where we've trying to take people into." 	C
End user engagement	<ul style="list-style-type: none"> Ability to engage users throughout the design and implementation process, to build rapport with them; Ability to build networks and enrol people behind an idea; Ability to sell an idea. 	C
Advanced ICT literacy; Advanced Information literacy	<ul style="list-style-type: none"> A sufficient technical understanding of the software being developed (if the innovation entail software), its affordances and functionality required. Sufficient understanding of Human-Computer Interaction. An Implementation Facilitator needs to understand what the tech does, and how to use it, but not necessarily <i>how</i> the tech does what it does. 	I
Research, Data analysis	<ul style="list-style-type: none"> Ability to gather necessary evidence to support the rationale for taking the implementation project forward (national lead) Data analytics, strategic analysis 	I
Training skills	<ul style="list-style-type: none"> User training: ability to explain users how and why to use the software, how to embed it as part of practice; doing technology demos and showing examples of where it's worked elsewhere, encouraging the clinicians to engage then with the requirements analysis, so that they're actually part of the design. 	I
Project management skills Organisational skills; Productivity and accountability	<ul style="list-style-type: none"> Programme and portfolio management skills, keeping project on track; time management, keeping to deadlines; managing budget, setting mile stones; applying for funding. Setting project governance in place. Reporting, evaluation, manage facilitation on behalf of the partnerships; set the governance and make sure the project is very well run and auditable. Contract management and awareness of procurement which is required for implementation and 	I
Leadership skills	<ul style="list-style-type: none"> Leading the process of implementation and working with an interdisciplinary team; Confidence to make decisions. 	I
Collaboration	<ul style="list-style-type: none"> Collaboration skills; working jointly with different types of groups of people. 	I
Creativity and innovation	<ul style="list-style-type: none"> Implementation Facilitator role requires a lot of agility in thinking and planning; Thinking outside the box. 	I
Active learning and learning strategies	<ul style="list-style-type: none"> Ability to keep up to date in a fast-changing environment, and in working in different types of contexts. 	I
Cyber security (Knowledge and Skills; specialist)	<ul style="list-style-type: none"> Cyber Security – enough understanding of the issues to take cyber security aspects into account in your work. 	W

Business skills awareness	<ul style="list-style-type: none"> Market analysis Business case development 	W
Design	<ul style="list-style-type: none"> Understanding what good design looks like Understanding the process of design Understanding co-design principles <i>“Human behavioural change, human factors, aspects of ergonomics, design for usability – all the things that get the software, or any innovation, actually implemented”.</i> 	W
Technical IT-skills Coding and programming	<ul style="list-style-type: none"> Advanced IT-literacy is sufficient; basic understanding of technical IT issues Basic understanding of what coding and programming languages are and can do. 	B
Not mentioned for this category	n/a	NA
Personal attributes	<ul style="list-style-type: none"> Can do-attitude; importance of suitable personality; focussed; attention to detail; ability to see the whole and zoom into detail; good collaborator, communicator; confidence to make decision. 	

Appendix 5d: Full Skills and Capabilities Table for Knowledge Engineers

21 st Century Skills Plus	Capabilities and knowledge required as per data	Importance
Domain Specialism	<ul style="list-style-type: none"> In-depth understanding of what the work of the professionals in the field is like and what it entails; Ability to learn about the knowledge domain quickly. 	C
Advanced information Literacy	<ul style="list-style-type: none"> An understanding of currently existing data sets that could be brought together and analysed either using statistical or AI methods; Ability to recognise which sources to use: what is validated knowledge and guidance relating to the domain Ability to source and appraise both the research-based knowledge and the more tacit knowledge from experience, and to be able to weigh up the role that each of these are going to play in a final decision Ability to take in large amounts of information from diverse sources and quickly summarise into succinct argument; (Requirements analysis) <p><i>“That’s what drives it all, that’s where you get to Knowledge. What knowledge is actually needed to help the user with the problem that they have.”</i></p>	C
Research, data analysis and analytical skill	<ul style="list-style-type: none"> Excellent research and investigative skills Data Analysis Enquiry skills - the ability to question in order to really understand people Deep understanding of the entire decision-making process to analyse workflow, flow of information, processes and behaviours. Understanding the extent to which professional judgement and the citizen’s lived experience has a role to play in decision-making. <p><i>“Even a simple decision can be remarkably complicated once you get under the skin of all the possible elements that go into a decision”</i></p>	C
Critical thinking, complex problem-solving and analysis	<ul style="list-style-type: none"> Problem-articulation Ability to drill down into a problem. Ability to comprehend and solve complex problems. Ability to break the <i>decision-making process</i> into its individual knowledge-elements (deconstruct) and to re-engineer it to construct the necessary algorithms and the complex decision-trees. Ability to analyse, break down and reorganise the <i>available knowledge</i> into meaningful patterns to be organised into relevant information for the purpose required (e.g. clinical decision support). <p><i>“Organising and managing the navigation and the user experience of the data effectively requires a lot of analytical insight and engagement with the user”</i></p>	C
Emotional intelligence Change management	<ul style="list-style-type: none"> Empathy with the user and their situation Ability to manage the change of work flows and practices with the stakeholders. 	C

Communication skills	<ul style="list-style-type: none"> • Ability to listen, communicate • Ability to elucidate user needs and articulate these; • Ability to communicate findings and demonstrate evidence to decision makers so that they can see what the evidence is telling them and what the next steps should be. 	C
Collaboration	<ul style="list-style-type: none"> • Excellent collaboration and team-working skills 	C
End user engagement	<ul style="list-style-type: none"> • Ability to engage with users, understand and articulate their needs and challenges, drill down to a problem, help users understand what kind of solution will help them (requirements analysis) 	C
Organisational skills (productivity and accountability)	<ul style="list-style-type: none"> • An organised approach to their job • The ability to deliver highly complex projects. • Digital content management • Metadata management 	I
Creativity, originality and initiative	<ul style="list-style-type: none"> • Ability to think outside the box, ability to come up with new ideas and new way to do things • Innovative thinking 	I
Technical IT-skills Advanced ICT literacy	<ul style="list-style-type: none"> • Excellent technical IT skills and understanding of algorithms and AI required • Advanced IT literacy assumed. • 	I
Coding/programming languages	<ul style="list-style-type: none"> • Understanding of coding and programming languages required; • Understanding of data driven generation of knowledge essential. • Some understanding of data driven approaches; • Organising and managing the navigation and the user experience of the data • Ability to test the re-engineered algorithms in practice 	I
Design	<ul style="list-style-type: none"> • Ability to design information architectures • Appreciation of what is good design 	I
Active learning and learning strategies	<ul style="list-style-type: none"> • Having an enquiring mind; • Ability to learn new things quickly 	I
Project Management Skills	<ul style="list-style-type: none"> • Knowledge Engineering work requires the ability to manage a complex development project from start to finish. May not require similarly extensive project management skills as a FI, but still important. 	I
Systems analysis and evaluation; Quality improvement	<ul style="list-style-type: none"> • Working awareness of systems analysis and evaluation processes and quality improvement aspects of the software project. 	W
Cyber Security	<ul style="list-style-type: none"> • Cyber Security – enough understanding of the issues to take cyber security aspects into account in your work. 	W
Business Awareness	<ul style="list-style-type: none"> • Enough business awareness to understand how AI will sit within the structure and benefit the service/system overall. 	W
Training skills	<ul style="list-style-type: none"> • End user training 	W
Not mentioned in this category	n/a	NA
Personal attributes	<ul style="list-style-type: none"> • Really enjoys working with data 	

Appendix 5e: Full Skills and Capabilities Table for Health Data Analysts

21 st Century Skills Plus	Capabilities and knowledge required as per data	Importance
Research, data analysis, analytical skills	<ul style="list-style-type: none"> Relevant research and data skills; Data collection, manipulation and analysis skills; Ability to use structured query language to query databases to get the required data. 	C
Technical IT skills (Assumes Advanced IT literacy)	<ul style="list-style-type: none"> Excellent technical IT-skills; Ability to use various software packages: Spreadsheet skills; ability to use <i>Excel</i>, <i>SPSS</i> and <i>Business objects</i>; (<i>Tableau</i>, <i>Shiny</i> also mentioned); business intelligence analysis tools called <i>Micro-strategy</i> Data-warehousing skills 	C
Coding/ programming languages Design	<ul style="list-style-type: none"> Good knowledge of and ability to use and work with programming languages. SQL the most useful for the NHS; R and Python are used sometimes. SQL server and database management and design skills; <p><i>“The Microsoft SQL server is THE industry standard in databases and sequel databases, and ALL of our IT systems link to, or work on Microsoft SQL server.- -So, you really have to have an understanding of SQL, a really good grounding on SQL”.</i></p>	C
Information literacy	<ul style="list-style-type: none"> Ability to appraise data sources; requirements; methods of analysis etc. 	I
Organisational skills (productivity & accountability)	<ul style="list-style-type: none"> Organisational skills Meticulous and organised approach to work 	I
Communication skills	<ul style="list-style-type: none"> Ability to communicate findings in a meaningful way. Creating visualisations - really important for presenting data in a useful way 	I
Active learning and learning strategies	<ul style="list-style-type: none"> Curious, inquisitive mindset Ability to learn on the job 	I
Project Management skills	<ul style="list-style-type: none"> Ability to manage own workload Ability to work to deadlines 	W
End user engagement	<ul style="list-style-type: none"> Ability to listen carefully to understand people’s information needs 	W
Collaboration	<ul style="list-style-type: none"> Data analysts more often work independently. Some collaboration skills may be required depending on the project they are working on. 	W
Creativity, originality and initiative	<ul style="list-style-type: none"> Health data analysts primarily manipulate and analyse “dead numbers”. The job does not require a lot of creativity or originality. Again, this can be a context dependent quality. 	W

Business awareness	<ul style="list-style-type: none"> Ability to use data to support the business of running a health care organisation. 	W
Emotional intelligence	<ul style="list-style-type: none"> Some emotional intelligence is required in elucidating what data and information is required by the management. 	W
Domain specialism	<ul style="list-style-type: none"> Basic understanding of the Health and Care context required to understand the data and information needs, and how the data gets generated and 	W
Critical thinking, complex problem-solving and analysis	<ul style="list-style-type: none"> Ability to critically assess data and analyse it <i>“---to be honest, people who have done complicated stats, if they’ve done Maths, they really won’t like working with us, unless they can radically adjust your brain, because we don’t use complicated maths or stats in what we do. It is just basically: pull out a lot of dead numbers, do some simple things, and then put in a nice visualisation that you can then go explain to people and say this is what is going on.”</i> 	W
Cyber security	<ul style="list-style-type: none"> Cyber Security – enough understanding of the issues to take cyber security aspects into account in your work. 	W
Systems analysis and evaluation; Quality improvement	<ul style="list-style-type: none"> Basic understanding of systems analysis and evaluation processes and quality improvement aspects required. Context dependent skill. 	B
Not mentioned	<ul style="list-style-type: none"> Facilitation skills Change Management Training skills 	NA
Personal attributes	<ul style="list-style-type: none"> Aptitude for numeracy; accuracy, attention to detail, ability focus, interest in working with data; analytic approach to work; curious, inquisitive mindset; ability to work independently. 	

Appendix 5f: Full Skills and Capabilities Table for Cyber Security Consultant

21 st Century Skills Plus	Capabilities and knowledge required as per data	Importance
Cyber security (Knowledge and skills)	<ul style="list-style-type: none"> Understanding of cyber security on systems level Understanding user-related cyber security issues Knowledge of cyber security behaviours and good practices Ability to recognise cyber security threats Knowledge and skill to deal with cyber security threats Ability to understand the range of diverse types of impact a cyber security breach would cause for the sector and its employees 	C
Communication skills	<ul style="list-style-type: none"> Ability to explain complex problems in laymen's terms, because not everybody is versed in cyber security; Ability to understand, articulate and explain the impact a cyber security breach could cause the company and the workforce (financial, operational, social, practical, reputational etc.) Ability to impart knowledge <i>Key requirement</i> 	C
Active Learning and learning strategies	<ul style="list-style-type: none"> Curiosity, inquisitive mindset Ability to keep up to date with a fast-changing digital world 	C
Domain specialism	<ul style="list-style-type: none"> In-depth understanding of the nature of the sector in question and the way it operates, its needs and practices. This is required to be able to understand the threats that the industry is facing. 	C
Advanced Information literacy	<ul style="list-style-type: none"> Ability to source and assess relevant information from a variety of sources 	C
End user engagement	<ul style="list-style-type: none"> Ability to work with people using the technologies, listening to their concerns and training needs. 	C
Training skills	<ul style="list-style-type: none"> Ability to train peers in cyber security issues, behaviours and good practices; Ability to create training and information materials on the topic. 	I
Advanced ICT literacy	<ul style="list-style-type: none"> Working knowledge and overall understanding of computer systems, devices and how these work. (Need to know what they do, but not necessarily <i>how</i> they operate) 	I
Emotional intelligence	<ul style="list-style-type: none"> Ability to read people and situation in order to support them in their cyber security journeys. 	I
Critical thinking, complex problem solving and analysis	<ul style="list-style-type: none"> The role requires an ability to critically appraise issues that peers may bring forth regarding cyber security related questions. The role does not require ability to solve complex problems. 	W
Collaboration	<ul style="list-style-type: none"> Basic ability to collaborate with others required to arrange and deliver training 	W
Creativity, originality and initiative Project management skills	<ul style="list-style-type: none"> The role requires basic understanding of project management skills and business awareness Delivery of the role does not require high levels of creativity or originality. 	B

Business awareness		
Technical IT-skill	<ul style="list-style-type: none"> Advanced IT-literacy is enough for this role 	B
Not mentioned	<ul style="list-style-type: none"> Design Systems analysis and evaluation Coding and programming languages Research, Data analysis, analytical skills Facilitation skill Change management 	NA
Personal attributes	<ul style="list-style-type: none"> Interest in cyber security Likes working with different types of people Proactive personality 	

Appendix 5g: Full Skills and Capabilities Table for Cyber Security Administrator

21 st Century Skills Plus	Capabilities and knowledge required as per data	Importance
Technical IT skills	<ul style="list-style-type: none"> Excellent computer science skills A full understanding of how the information flows in the networked system and connected devices and apps. 	C
Cyber security skills and knowledge	<ul style="list-style-type: none"> In-depth understanding of Cyber Security networking A full understanding of what the critical points to secure are in order to prevent data from leaking or other security breaches. Ability to recognise cyber security threats and to prevent or block these Ability to understand the range of diverse types of impacts a cyber security breach would cause for the sector and its employees 	C
Active Learning and learning strategies	<ul style="list-style-type: none"> Curiosity, inquisitive mindset Interest in cyber security 	C
Design Coding and Programming languages	<ul style="list-style-type: none"> Programming and (computer) networking skills; Ability to interact with a number of networked, inter-connected systems 	I
Systems analysis and evaluation + Qual imp	<ul style="list-style-type: none"> A full understanding of all the elements of the infrastructure, including devices and apps connected to it one way or another 	I
Communication skills	<ul style="list-style-type: none"> Ability to effectively communicate existing threats to a variety of audiences; Ability to effectively articulate the impact that the threat has on the organisation and employees etc. 	I
Critical thinking, complex problem solving and analysis	<ul style="list-style-type: none"> Ability to recognise, comprehend and solve complex problems. Problem-articulation Ability to drill down into a problem. 	I
Advanced information literacy	<ul style="list-style-type: none"> Ability to source and understand relevant information. 	I
Creativity, originality and initiative	<ul style="list-style-type: none"> Ability to think outside the box Ability approach problems creatively, find new ways of solving problems Creativity 	I
Collaboration Emotional intelligence	<ul style="list-style-type: none"> Systems facing role that requires ability to collaborate with the Cyber security team and others related to the domain, and some emotional intelligence to deliver customer service as part of your work. 	W
Domain specialism	<ul style="list-style-type: none"> Working knowledge and understanding of Health and Care sector and how it operates helps, but is not essential. 	W
Business skills	<ul style="list-style-type: none"> Basic knowledge of the business needs of the sector good to have but not essential. 	B
Project management skills	Basic knowledge of project management ability and skills required: working to deadline, managing own workload, meeting targets etc.	B

End user engagement	<ul style="list-style-type: none"> • This is primarily a systems oriented role; some end user engagement is possible in dealing with cyber security issues and problems. 	B
Not mentioned	<ul style="list-style-type: none"> • Research, Data analysis, analytical skills • Facilitation skill • Change management • Training skills 	NA
Personal attributes	<ul style="list-style-type: none"> • Attention to detail; systems thinking; enquiring mind, ability to drill down to a problem; • Enjoying problem solving, creativity • Logical thinking • Technical mindset • Proactive personality 	

Appendix 5h: Full Skills and Capabilities Table for Cyber Security Architect

21 st Century Skills Plus	Capabilities and knowledge required as per data	Importance
Technical IT skills Coding and Programming languages Systems analysis and evaluation + Qual imp	<ul style="list-style-type: none"> Software design/engineering / computing background; A full understanding of all the elements of the infrastructure, including devices and apps connected to it one way or another; A full understanding of how the information flows in the networked system and connected devices and apps. Systems thinking 	C
Cyber security skills and knowledge	<ul style="list-style-type: none"> In-depth understanding of Cyber Security issues and cryptography; In-depth understanding of Cyber Security networking A full understanding of what the critical points of the system are to secure, in order to prevent data from leaking, or other security breaches happening. Ability to foresee and envisage different types of cyber security threats and respond to these in the design. Ability to incorporate security measures into the systems design at all levels. Knowledge of various rules, laws, regulations and recommendations relating to data and information governance and security. 	C
Design	<ul style="list-style-type: none"> Ability to design complex systems Appreciation of good design Understanding the purpose of the system, and its usability issues. Understanding how the various laws, rules, regulations and recommendations relating to data and information governance, privacy and security affect the design of the system. <p><i>"Each time you design a component, you need to be able to say, that component is secure. System architect would actually discuss that with the team. He'd expect the team be security software analysts, or programmers who are able to design secure software for the architect. And integrate the entire platform."</i></p>	C
End user engagement	<ul style="list-style-type: none"> Understanding of who will use the system Ability to elucidate and understand the types of cyber security concerns end users will have 	C
Active Learning and learning strategies	<ul style="list-style-type: none"> Ability to continuously learn, and keep up-to-date with latest IT and cyber security developments Enquiring mind; curiosity 	C
Creativity, originality and initiative	<ul style="list-style-type: none"> Ability approach complex problems creatively, find new ways of solving problems; Ability to think outside the box 	I
Critical thinking, complex problem-solving, and analysis	<ul style="list-style-type: none"> Ability to approach problems critically Ability approach complex problems creatively, find new ways of solving problems; Ability to think outside the box Ability to think ahead and anticipate potential future threats. 	I

Communication skills	<ul style="list-style-type: none"> • Ability to communicate with diverse audiences and different professional groups; • Ability to articulate complex ideas and translate these into models and systems. 	I
Project management skills Organisational skills	<ul style="list-style-type: none"> • Ability to see complex projects with multiple stakeholders, tight budget, competing demands to an end within the deadline. 	I
Active learning and learning strategies	<ul style="list-style-type: none"> • Curiosity; • Enquiring mind, ability to drill down to a problem; • Interest in cyber security • Keeping up to date with any latest developments in cyber security field. 	I
Collaboration	<ul style="list-style-type: none"> • Ability to work as part of an interdisciplinary team, but in a leadership position 	I
Domain specialism	<ul style="list-style-type: none"> • Understanding the needs of the Health and Care sector will help. This specialism might come from elsewhere in the team. 	W
Leadership	<ul style="list-style-type: none"> • usually an architect is going to be in charge of a team, so appropriate project management and leadership skills 	W
Emotional intelligence	<ul style="list-style-type: none"> • Ability to read people and situations, in order to elucidate user requirements. 	W
Business skills and awareness	<ul style="list-style-type: none"> • A working understanding of the business environment and its cyber security needs as part of the whole infrastructure required. 	W
Not mentioned	<ul style="list-style-type: none"> • Research, Data analysis, analytical skills • Facilitation skill • Change management • Training skills 	NA
Personal attributes	<ul style="list-style-type: none"> • Enjoys problem solving • Technical mindset • Attention to detail; systems thinking; • Leadership • Proactive personality, "Can do" attitude 	

Appendix 6: Heat Map

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Skills, capability, knowledge / Position	Communication	Active learning & learning strategies	Advanced Information literacy	Advanced ICT Literacy	Org. skills (productivity & accountability)	Critical thinking, complex problem-solving & analysis	Creativity, originality and initiative	Project/ programme Mgt skills	Collaboration	Design	Systems analysis and evaluation + Qual imp	Technical IT skill	Coding / programming languages	Emotional intelligence	Domain specialism (knowl of H&C)	End user engagement	Cyber security (knowledge and skills; specialist)	Business skills & Awareness	Research, Data Analysis, Analytical skill	Facilitation skills	Change management	Training skills
Software developer / engineer	I	I	I	I	I	I	I	I	I	C	I	C	C	I	B	C	I	W	NA	NA	NA	NA
Product Owner	C	I	I	I	I	I	I	I	I	W	W	B	B	C	C	C	W	I	NA	I	W	NA
Implementation Facilitator	C	I	I	I	I	C	I	I	I	W	C	B	B	C	C	C	W	W	I	C	C	I
Knowledge Engineer	C	I	C	I	I	C	I	I	I	I	W	I	I	C	C	C	W	W	C	I	C	W
Health Data Analyst	I	I	I	I	I	I	W	I	W	I	B	C	C	W	W	W	W	W	C	NA	NA	NA
Cyber security architect	I	C	I	I	I	I	I	I	I	C	C	C	C	W	W	W	C	W	I	NA	NA	NA
Cyber security "administrator"	I	C	I	I	I	I	I	B	W	I	I	C	I	W	W	B	C	B	NA	NA	NA	NA
Cyber security "consultant"	C	C	I	I	I	W	B	B	W	NA	NA	NA	NA	I	C	I	C	B	NA	NA	NA	I
	Crucial	C		Important	I		Requires working knowledge	W		Basic understanding	B		Not relevant / Not mentioned in data	NA			21st Century / WEF 2018			Emerged from our data		